NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

NASA SP-7037(217)
September 1987

National Aeronautics and Space Administration

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ACCESSION NUMBER RANGES

Accession numbers cited in this Supplement fall within the following ranges.

STAR (N-10000 Series)	N87-21846 — N87-23569
IAA (A-10000 Series)	A87-35191 — A87-39224

This bibliography was prepared by the NASA Scientific and Technical Information Facility operated for the National Aeronautics and Space Administration by RMS Associates.

NASA SP-7037(217)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 217)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in August 1987 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA Scientific and Technical Information Division 1987
National Aeronautics and Space Administration
Washington, DC

This supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22161, price code A07.

INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 450 reports, journal articles and other documents originally announced in August 1987 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cummulative index will be published.

Information on the availability of cited publications including addresses of organizations and NTIS price schedules is located at the back of this bibliography.

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Category 11	**Chemistry and Materials** Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.	**527**

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Includes engineering (general); communications and radar; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

Category 13 Geosciences 543

Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

Category 14 Life Sciences N.A.

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and space biology.

Category 15 Mathematical and Computer Sciences 544

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

Category 16 Physics 548

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

Category 17 Social Sciences 549

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

Category 18 Space Sciences N.A.

Includes space sciences (general); astronomy; astrophysics; lunar and planetary exploration; solar physics; and space radiation.

Category 19 General 550

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TYPICAL REPORT CITATION AND ABSTRACT

NASA SPONSORED

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ACCESSION NUMBER → **N87-10039*#** National Aeronautics and Space Administration. ← CORPORATE SOURCE
Langley Research Center, Hampton, Va.

TITLE → **WIND-TUNNEL INVESTIGATION OF THE FLIGHT CHARACTERISTICS OF A CANARD GENERAL-AVIATION AIRPLANE CONFIGURATION** — PUBLICATION DATE

AUTHOR → D. R. SATRAN Oct. 1986 60 p ← AVAILABILITY SOURCE

REPORT NUMBERS → (NASA-TP-2623; L-15929; NAS 1.60:2623) Avail: NTIS HC

PRICE CODE → A04/MF A01 CSCL 01A ← COSATI CODE

A 0.36-scale model of a canard general-aviation airplane with a single pusher propeller and winglets was tested in the Langley 30- by 60-Foot Wind Tunnel to determine the static and dynamic stability and control and free-flight behavior of the configuration. Model variables made testing of the model possible with the canard in high and low positions, with increased winglet area, with outboard wing leading-edge droop, with fuselage-mounted vertical fin and rudder, with enlarged rudders, with dual deflecting rudders, and with ailerons mounted closer to the wing tips. The basic model exhibited generally good longitudinal and lateral stability and control characteristics. The removal of an outboard leading-edge droop degraded roll damping and produced lightly damped roll (wing rock) oscillations. In general, the model exhibited very stable dihedral effect but weak directional stability. Rudder and aileron control power were sufficiently adequate for control of most flight conditions, but appeared to be relatively weak for maneuvering compared with those of more conventionally configured models.
Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT

NASA SPONSORED

ACCESSION NUMBER → **A87-11487*** National Aeronautics and Space Administration.
Ames Research Center, Moffett Field, Calif.

COMPUTATION OF TURBULENT SUPERSONIC FLOWS AROUND POINTED BODIES HAVING CROSSFLOW SEPARATION ← TITLE

AUTHORS → D. DEGANI and L. B. SCHIFF (NASA, Ames Research Center, Moffett Field, CA) ← AUTHOR'S AFFILIATION

JOURNAL TITLE → Journal of Computational Physics (ISSN 0021-9991), vol. 66, Sept. 1986, p. 173-196. refs

The numerical method developed by Schiff and Sturek (1980) on the basis of the thin-layer parabolized Navier-Stokes equations of Schiff and Steger (1980) is extended to the case of turbulent supersonic flows on pointed bodies at high angles of attack. The governing equations, the numerical scheme, and modifications to the algebraic eddy-viscosity turbulence model are described; and results for three cones and one ogive-cylinder body (obtained using grids of 50 nonuniformly spaced points in the radial direction between the body and the outer boundary) are presented graphically and compared with published experimental data. The grids employed are found to provide sufficient spatial resolution of the leeward-side vortices; when combined with the modified turbulence model, they are shown to permit accurate treatment of flows with large regions of crossflow separation. T.K.

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 217)

SEPTEMBER 1987

01

AERONAUTICS (GENERAL)

A87-35276
BASTART 85 - BONDED AIRCRAFT STRUCTURES, TECHNICAL APPLICATION AND REPAIR TECHNIQUES; PROCEEDINGS OF THE WORKSHOP, BREMEN, WEST GERMANY, JAN. 22-24, 1985
Workshop sponsored by the Deutsche Lufthansa AG and Fraunhofer-Institut fuer angewandte Materialforschung. Bremen, West Germany, Fraunhofer-Institut fuer angewandte Materialforschung, 1985, 322 p. For individual items see A87-35277 to A87-35281.

The present conference on state-of-the-art aircraft primary structure-bonding techniques gives attention to failure characteristics typical of bonded structures, representative bonded structure design features and applications, the projection of design trends in bonded metallic and composite aircraft structural elements, practical aspects of composite airframe temporary and permanent repair, the repair of primary and secondary structure joints after destruction, and the use of hot paste adhesives in the repair of metal/metal, metal/honeycomb, and composite/honeycomb components. Also discussed are experience with DC-9-80 advanced composites' paint-removal problems, development trends in composite structures for airliners, composite structural design practices in Airbus aircraft, and Lufthansa requirements for future metal and carbon fiber-reinforced bonded structural components. O.C.

A87-35277#
PRACTICAL ASPECTS FOR REPAIRING COMPOSITES
J. KOSHORST (Airbus Industrie, Toulouse, France) IN: BASTART 85 - Bonded aircraft structures, technical application and repair techniques; Proceedings of the Workshop, Bremen, West Germany, Jan. 22-24, 1985 . Bremen, West Germany, Fraunhofer-Institut fuer angewandte Materialforschung, 1985, 21 p.

A pragmatically-oriented account is given of contemporary airline operators' practices in the repair of representative composite primary and secondary structure types encountered on such state-of-the-art aircraft as the A310 airliner. Attention is given to the A310's inner airbrakes, fin box, rudder, and main landing gear leg fairing. The airbrake composite structure is subjected to a detailed repair method evaluation, with a view to both temporary and permanent repair measures, for a variety of possible damage types. O.C.

A87-35278#
BRITISH AIRWAYS ALTERNATIVE METHOD FOR THE REPAIR OF METAL/METAL, METAL/HONEYCOMB AND FIBREGLASS, CARBON-FIBRE OR KEVLAR/HONEYCOMB COMPONENTS USING HOT-SETTING FILM OR PASTE ADHESIVES
K. B. ARMSTRONG (British Airways, Hounslow, England) IN: BASTART 85 - Bonded aircraft structures, technical application and repair techniques; Proceedings of the Workshop, Bremen, West Germany, Jan. 22-24, 1985 . Bremen, West Germany, Fraunhofer-Institut fuer angewandte Materialforschung, 1985, 11 p.

A87-35279#
TODAYS REPAIR METHODS FOR COMPOSITES
PAUL VOS (Societe Anonyme Belge d'Exploitation de la Navigation Aerienne, Zavantem, Belgium) IN: BASTART 85 - Bonded aircraft structures, technical application and repair techniques; Proceedings of the Workshop, Bremen, West Germany, Jan. 22-24, 1985 . Bremen, West Germany, Fraunhofer-Institut fuer angewandte Materialforschung, 1985, 22 p.

An evaluation is presented of temporary and permanent repair methods for composite structural components encountered in the B767 and A310 airliners, as testified by four airlines employing in-house repairs to aramid- and carbon-fiber reinforced polymers. The most common repair method involves the application of room temperature-setting epoxy resin systems with wet layup, which are subsequently cured at moderate temperatures under a vacuum bag either in an oven or under electric blankets. Types of damage encompass delamination, puncture, cracking, crushing, denting, and lightning strikes. O.C.

A87-35280#
COMPOSITES IN FUTURE
J. KOSHORST (Airbus Industrie, Toulouse, France) IN: BASTART 85 - Bonded aircraft structures, technical application and repair techniques; Proceedings of the Workshop, Bremen, West Germany, Jan. 22-24, 1985 . Bremen, West Germany, Fraunhofer-Institut fuer angewandte Materialforschung, 1985, 17 p.

An account is given of promising composite material structural design features and manufacturing methods that have been identified in the course of the development of the A300, A310 and A320 airliners, with a view to their economic and performance capability consequences for the next generation of commercial aircraft. Trends are identified and projected forward for the degree of composites' incorporation into airliner primary and secondary structures and the challenge again posed by metallic airframe structures in the wake of aluminum-lithium alloys' development. Attention is given to a highly modularized structural configuration and fabrication concept for empenage elements. O.C.

A87-35283#
THE NEED FOR NEW TECHNOLOGIES FOR THE U.S. AEROSPACE INDUSTRY
ALAN M. LOVELACE (General Dynamics Corp., Saint Louis, MO) IN: Computerized aerospace materials data; Proceedings of the Workshop on Computerized Property Materials and Design Data for the Aerospace Industry, El Segundo, CA, June 23-25, 1986 . New York, American Institute of Aeronautics and Astronautics, Inc., 1987, p. 13-17.

Rapidly advancing technologies, materials technologies among them, have produced discontinuities in the progress of technologies, e.g., the overlap between the use of piston and jet engines. A new technology enters development with performance levels surpassing an old technology before the old technology is fully mature. Monitoring the advances is therefore a critical matter for competing organizations, particularly aerospace manufacturers who may witness transitions over a period of months. It is recommended that a computerized materials database be developed for the U.S. as a means for manufacturers to track national and worldwide advances in new materials and the means to produce and use them. M.S.K.

A87-36583
AIRCRAFT ASSEMBLY PROCESSES [TEKHNOLOGIIA SBORKI SAMOLETOV]
VLADISLAV IVANOVICH ERSHOV, VIKTOR VLADIMIROVICH PAVLOV, MIKHAIL FILIPPOVICH KASHIRIN, and VADIM SERGEEVICH KHUKHOREV Moscow, Izdatel'stvo Mashinostroenie, 1986, 456 p. In Russian. refs

The theory of aircraft assembly and the principal assembly processes are reviewed with particular attention to methods of computer-aided manufacture. Topics discussed include mathematical modeling of aircraft assembly organization; interchangeability of structural elements during assembly; typical assembly processes; and automatic control of the specialized equipment of assembly shops. Attention is also given to the evaluation of the cost effectiveness of aircraft assembly processes; design of assembly processes; and software support of CAD/CAM systems. V.L.

A87-36751
YEARBOOK 1986 I; DGLR, ANNUAL MEETING, MUNICH, WEST GERMANY, OCT. 8-10, 1986, REPORTS [JAHRBUCH 1986 I; DGLR, JAHRESTAGUNG, MUNICH, WEST GERMANY, OCT. 8-10, 1986, VORTRAEGE]
Meeting sponsored by DGLR. Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, 405 p. In German and English. For individual items see A87-36752 to A87-36797.

A collection of papers on air travel and space travel science and technology is presented. The general topics addressed include: propulsion and control, systems, and loads in space travel; air transport systems, performance, and propulsion; AI tools, sensors, and diagnostics; application of AI in object recognition; the man-machine interface; theoretical and experimental aerodynamics and thermodynamics; materials and construction; and the history of air and space flight. C.D.

A87-36940
REPAIR CONCEPT AND VERIFICATION FOR CARBON HIGH-LIFT FLAPS OF THE ATR.42 [LA CONCEPTION ET LE CONTROLE DES REPARATIONS DES VOLETS HYPERSUSTENTATEURS DE L'ATR.42 EN CARBONE]
GUY HELLARD (Aerospatiale, Toulouse, France) (NATO, AGARD, Meeting, 62nd, Oslo, Norway, Apr. 14-18, 1986) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 120, 1986, p. 3-10. In French.

Following a discussion of the composite materials used in the ATR.42 aircraft, criteria for the repair of the carbon high-lift flaps for the various damage types, and results of repair testing are presented. It is noted that flap repair should be able to sustain aging and fatigue up to 50 C. The adopted repair technology consists of two types of carbon materials impregnated in situ with a Redux 501 resin which has been polymerized at 80 C under pressure. Only provisional repair is recommended for cases including shocks. Preliminary tests included the definition of the adhesion characteristics of Redux 501 for aged and nonaged materials up to 80 C. Internal flap testing consisted of verification of the structure during fatigue, and determination of the damage tolerance of composite parts and the quality of repairs. Tests on the quality of repair of various fabrication defects are also considered. R.R.

A87-36941
REPAIR OF HELICOPTER STRUCTURAL COMPOSITES - TECHNIQUES AND THEIR VALIDATIONS [REPARATIONS DES STRUCTURES COMPOSITES D'HELICOPTERES - LES TECHNIQUES ET LEURS JUSTIFICATIONS]
M. TORRES and B. PLISSONNEAU (Aerospatiale, Marignane, France) (NATO, AGARD, Meeting, 62nd, Oslo, Norway, Apr. 14-18, 1986) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 120, 1986, p. 11-28. In French.

Various types of damage to helicopter structural composites, their repair, and the validation of their repair are considered. The use of metal reinforcements with preimpregnated dry materials is reserved for vital parts. Repair methods using bicomponent adhesives polymerizing at ambient temperature are tested: (1) in the test specimen's initial state; (2) after accelerated humid-environment aging; and (3) at the maximum temperature experienced by the part. Good agreement is found between experimental results and predictions obtained using a finite element method. Results demonstrate the importance of the use of reinforcements which are compatible with the deformed material, and the influence of the repair mode (glueing versus riveting) on the repair characteristics. R.R.

A87-36942
IN-SERVICE DAMAGE REPAIR OF STRUCTURAL COMPOSITES APPLICATION TO THE MIRAGE 2000 [REPARATION DE DOMMAGES EN SERVICE DES STRUCTURES COMPOSITES APPLICATION AU MIRAGE 2000]
DANIEL CHAUMETTE and FRANCOISE HENRIOT (Avions Marcel Dassault Breguet Aviation, Saint-Cloud, France) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 120, 1986, p. 29-35. In French.

In-service damage repair of structural composites is discussed and applied to the composite parts of the Mirage 2000 (elevons, fins, rudders, and several doors and panels). Repair zones and a classification of parts according to importance are considered for the Mirage 2000, and results of repair verification for various conditions are presented. Studies on the optimization of repair design show the feasibility, for certain cases, of reinforcements and repairs using a dry-fabric boron fiber and carbon adhesives bonded and impregnated in situ on aluminum structures. Though repair does not reconstitute the original part strength, a strength superior to that obtained in calculations of extreme loading is found. R.R.

A87-38654#
XMAN - AN EXPERT MAINTENANCE TOOL
TIMOTHY G. JELLISON, NIGEL S. PRATT, J. DAN PEHOUSHEK, LINDA JO DOLNY, and RONALD L. DE HOFF (Systems Control Technology, Inc., Palo Alto, CA) IN: AUTOTESTCON '86; Proceedings of the International Automatic Testing Conference, San Antonio, TX, Sept. 8-11, 1986 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 29-35.

XMAN, an expert system for jet engine diagnostics and maintenance, applicable to the Engine Diagnostics/Comprehensive Engine Management System Increment IV (ED/CEMS IV) is discussed. XMAN is a knowledge-based system composed of three modular software elements: a knowledge base, a data base, and a control system. XMAN is written in Common LISP and extracts facts from the data base of the ED/CEMS IV employable in the troubleshooting/fault isolation process. The complete XMAN operation sequence, and the characteristics of the modular elements are described. The troubleshooting capability of XMAN is illustrated by applying XMAN to the maintenance of TF34 engines

of A-10 aircraft equipped with turbine engine monitoring systems. I.F.

A87-38656#
AFTA - A PLATFORM TO EXPERT SYSTEMS IN ATE
J. LUIS HERNANDEZ (Computer Systems Development Corp., Fairfax, VA) IN: AUTOTESTCON '86; Proceedings of the International Automatic Testing Conference, San Antonio, TX, Sept. 8-11, 1986 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 51-55. refs

The development and operation of the Avionics Fault Tree Analyzer (AFTA) are described. AFTA is a portable, microprocessor-based computer system which executes fault isolation programs and performs automatic testing of avionics systems in their operational environment. The fault isolation programs are referred to as fault trees; the fault tree design is based on the effectiveness of the avionics system built-in test and the knowledge and practical expertise of the fault tree designer. The execution of a fault tree includes analyzing, sorting, comparing, examining, and manipulating the data from the system being tested. It is determined that the system is effective, but not a replacement for conventional ATE. The expert system characteristics of AFTA, and the development of an expert system for ATE are considered. I.F.

N87-21846# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
AIR FORCE TECHNICAL OBJECTIVE DOCUMENT, FLIGHT DYNAMICS LABORATORY PLANS FOR FISCAL YEAR 1988 Final Report, Aug. 1985 - Jul. 1986
Jul. 1986 63 p Supersedes AFWAL-TR-85-3000
(AD-A176115; AFWAL-TR-86-3000; AFWAL-TR-85-3000) Avail: NTIS HC A04/MF A01 CSCL 01C

This document presents an overview of the Laboratory Technology Planning Objectives of the Flight Dynamics Laboratory omitting specific funding and timing information of an Official Use Only nature. Technology planning objectives are described for structures and dynamics, vehicle equipment, flight control, aeromechanics, and technology assessment. GRA

N87-21847# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
ACTA AERODYNAMICA SINICA
6 Jan. 1987 247 p Transl. into ENGLISH of Kongqidongliuxue Xuebao (China), v. 3, no. 4, 1985 p 1-120
(AD-A176552; FTD-ID(RS)T-0368-86) Avail: NTIS HC A11/MF A01 CSCL 20D

Acta Aerodynamica Sinica, v. 3, n. 4, 1985 contains the following: Behavior of Separation Lines in a Steady Viscous Flow Based on Analysis of Boundary Layer Equations; Numerical Prediction of Supersonic Boundary Layer Transition; Iterative Method to Determine Feedback Coefficients for Multiloop Systems; Movement of Hydrometeor Particles in a Bow Shock Layer; Numerical Calculations for Inviscid Transonic Flow Over Two-Dimensional Cascades; Kernel Function Method for Unsteady Transonic Flow Past Low-Frequency Oscillating Bodies of Revolution; Numerical Computation of Turbulent Jet Fields Using Two-Equation Turbulent Model; An Optimal Formulation of Simplified Three-Dimensional Navier Stokes Equations; Numerical Solution of Viscous Flows at Low Reynolds Number; Normal Force Characteristics of Sharp Nosed Bodies of Revolution at High Angle of Attack in Subsonic and Transonic Flow; Method of Differentiating Interpolation Function in Solving Some Partial Differential Equations; Applicability and Linkage of First Order and Second Order Shock Expansion Methods; and the Improvement of Unsteady Aerodynamic Methods for rotor Blade Lift Surface. GRA

N87-21848# Air War Coll., Maxwell AFB, Ala.
FUTURE FIGHTERS: WILL THEY BE SUPPORTABLE?
GEORGE T. BABBITT Mar. 1986 26 p
(AD-A177790; AU-AWC-86-013) Avail: NTIS HC A03/MF A01 CSCL 01C

The author discussed requirements for support of future fighters. Conceptual design work is underway for the Advanced Tactical Fighter which the Air Force hopes to field in the mid to late 1990s. Two areas critical to improved supportability are examined: defining the combat environment and improving reliability. Both areas are discussed in terms of new policy guidance and in terms of technical issues now under study. The author concludes that important changes have been made to the way the Air Force approaches the problem of supportability and that research currently underway promises to make future fighters more supportable than current fighters. GRA

N87-21849*# Lockheed-Georgia Co., Marietta.
DEVELOPMENT OF LAMINAR FLOW CONTROL WING SURFACE COMPOSITE STRUCTURES Final Report
L. B. LINEBERGER et al. May 1984 135 p
(Contract NAS1-17487)
(NASA-CR-172330; NAS 1.26:172330; LG84ER0035) Avail: NTIS HC A07/MF A01 CSCL 01A

The dramatic increases in fuel costs and the potential for periods of limited fuel availability provided the impetus to explore technologies to reduce transport aircraft fuel consumption. NASA sponsored the Aircraft Energy Efficiency (ACEE) program beginning in 1976 to develop technologies to improve fuel efficiency. This report documents the Lockheed-Georgia Company accomplishments under NAS1-16235 LFC Laminar-Flow-Control Wing Panel Structural Design and Development (WSSD); Design, manufacturing, and testing activities. An in-depth preliminary design of the baseline 1993 LFC wing was accomplished. A surface panel using the Lockheed graphite/epoxy integrated LFC wing box structural concept was designed. The concept was shown by analysis to be structurally efficient and cost effective. Critical details of the surface and surface joints were demonstrated by fabricating and testing complex, concept selection specimens. Cost of the baseline LFC aircraft was estimated and compared to the turbulent aircraft. The mission fuel weight was 21.7 percent lower for the LFC aircraft. The calculation shows that the lower fuel costs for LFC offset the higher incremental costs of LFC in less than six months. Author

N87-22604*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
JOINT UNIVERSITY PROGRAM FOR AIR TRANSPORTATION RESEARCH, 1984
FREDERICK R. MORRELL, comp. May 1987 165 p Meeting held in Hampton, Va., 18 Jan. 1985
(NASA-CP-2452; L-16255; NAS 1.55:2452) Avail: NTIS HC A08/MF A01 CSCL 01B

The research conducted during 1984 under the NASA/FAA sponsored Joint University Program for Air Transportation Research is summarized. The Joint University Program is a coordinated set of three grants sponsored by NASA Langley Research Center and the Federal Aviation Administration, one each with the Massachusetts Institute of Technology, Ohio University, and Princeton University. Completed works, status reports, and bibliographies are presented for research topics, which include navigation, guidance, control and display concepts. An overview of the year's activities for each of the schools is also presented.

N87-22664# Ministry of Defence, London (England).
COST ANALYSIS OF AIRCRAFT PROJECTS
D. FADDY *In* AGARD Improvement of Combat Performance for Existing and Future Aircraft 10 p Dec. 1986
Avail: NTIS HC A07/MF A01

The effect of advancing technology on the cost of past aircraft and the implications for the future is reviewed. The validity of historical records for forecasting a future dominated by technological change and the consequences of continued

escalation are discussed. It is argued that more priority needs to be given to the reduction of support cost and a way of looking at this as a direct contribution to military capability is suggested. The role of operations research is briefly emphasized and a more deliberately evolutionary approach to the production of aircraft is advocated. Author

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A87-35552
A METHOD FOR COMPUTING FLOW FIELDS AROUND MOVING BODIES
SATORU OGAWA and TOMIKO ISHIGURO (National Aerospace Laboratory, Chofu, Japan) Journal of Computational Physics (ISSN 0021-9991), vol. 69, March 1987, p. 49-68. refs

The present flow field computation method for fields with arbitrarily moving boundaries uses Lie derivatives to yield the field equations in general moving coordinates; the formulation used for the several kinds of equations thus obtained renders the movement of the computational coordinates fitted to the body practicable. The finite difference method is used to solve the two-dimensional incompressible Navier-Stokes equations in general moving coordinates for the cases of the flow of blood in the ventricle of a human heart and the dynamic stall process of an oscillating airfoil. O.C.

A87-35813
STRUCTURE AND PULSATION CHARACTERISTICS OF A COMPRESSIBLE TURBULENT BOUNDARY LAYER BEHIND A FAN OF RAREFACTION WAVES [STRUKTURA I PUL'SATSIONNYE KHARAKTERISTIKI SZHIMAEMOGO TURBULENTNOGO POGRANICHNOGO SLOIA ZA VEEROM VOLN RAZREZHENIIA]
M. A. GOLDFELD, V. N. ZINOVEV, and V. A. LEBIGA Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Jan.-Feb. 1987, p. 48-53. In Russian. refs

The development of an axisymmetric turbulent boundary layer following its interaction with a fan of rarefaction waves is investigated experimentally for M=3, a unit Reynolds number of 36 x 10 to the 6th per m, and a flow turn angle of 15 deg. It is shown that, due to a large negative pressure gradient, the fullness of the mean velocity profile directly behind the fan of rarefaction waves increases (with a simultaneous decrease in mass flow pulsation) and then decreases rapidly downstream to equilibrium at a distance of approximately 50 times the boundary layer thickness from the contour bend. A comparison is made with results obtained for plane flow. V.L.

A87-35816
TRANSONIC GAS FLOW PAST A PLATE [OBTEKANIE PLASTINKI OKOLOZVUKOVYM POTOKOM GAZA]
S. K. ASLANOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Jan.-Feb. 1987, p. 128-137. In Russian. refs

A solution is presented for the two-sided Tricomi problem arising in the hodograph plane. The solution satisfies a full set of boundary conditions, which ensures its correct asymptotic behavior with respect to the vanishing angle of attack. It is shown that the difference between Guderlei's (1954) solution and the solution proposed here starts with the singular terms. V.L.

A87-35817
A SOLUTION TO THE VARIATIONAL PROBLEM OF THE OPTIMAL SHAPE OF SUPERSONIC NOZZLES [K RESHENIIU VARIATSIONNOI ZADACHI OB OPTIMAL'NOI FORME SVERKHZVUKOVYKH SOPEL]
A. A. SERGIENKO and A. A. SOBACHKIN Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Jan.-Feb. 1987, p. 138-142. In Russian.

The variational problem of the optimal shape of supersonic nozzles is analyzed using a formulation that does not stipulate a vanishing term in the first variation of the Lagrange functional. The region of existence of a solution to the resulting boundary value problem is examined. Calculations are carried out for such a problem, with the isolation of both an extreme of a known type and uknown boundary extremes. V.L.

A87-35822
AN EXPERIMENTAL STUDY OF THE STRUCTURE OF COAXIAL NONISOBARIC REACTING JETS [EKSPERIMENTAL'NOE ISSLEDOVANIE STRUKTURY KOAKSIAL'NYKH NEIZOBARICHESKIKH REAGIRUIUSHCHIKH STRUI]
S. I. BARANOVSKII, V. M. LEVIN, and A. I. TURISHCHEV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Jan.-Feb. 1987, p. 184-186. In Russian.

The structure of coaxial nonisobaric reacting jets consisting of hydrogen, oxygen, and gasoline combustion products is investigated experimentally using static pressure measurements and visualization techniques. It is shown that the axial distribution of static pressure and the ignition delay are largely determined by the external jet characteristics and are practically independent of the internal-to-external pressure ratio of the internal nozzle and of the fuel flow rate through the nozzle. The fuel of the central jet self-ignites in a zone where both the mixture composition and temperature achieve the ignition level. V.L.

A87-35824
A STUDY OF THE EFFECT OF THE SEPARATION ZONE ON THE OSCILLATIONS OF A CONE [K ISSLEDOVANIIU VLIIANIIA OTRYVNOI ZONY NA KOLEBANIIA KONUSA]
V. A. PLATONOV and V. N. SHMANENKOV Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza (ISSN 0568-5281), Jan.-Feb. 1987, p. 190, 191. In Russian.

The factors responsible for the dynamic loss of stability of a cone with a circular conical stabilizer are investigated numerically in the context of linear theory for bodies of finite thickness. It is found that, for such cones, the dynamic loss of stability in hypersonic flow is largely due to the inertia of the flow separation zone, which should be taken into account in aerodynamic calculations. The results are supported by wind-tunnel test data. V.L.

A87-35916
ASPECTS OF THE CALCULATION OF POTENTIAL FLOW PAST A SLAT IN A SYSTEM OF AIRFOIL PROFILES [OB OSOBENNOSTIAKH RASCHETA POTENTSIAL'NOGO OBTEKANIIA PREDKRYLKA V SISTEME AERODINAMICHESKIKH PROFILEI]
A. A. ZAITSEV and A. M. KOMAROV Moskovskii Universitet, Vestnik, Seriia 1 - Matematika, Mekhanika (ISSN 0579-9368), no. 6, Nov.-Dec. 1986, p. 42-46. In Russian.

A method for calculating potential flow past a system of airfoil profiles is developed which employs special parametrization reflecting the characteristics of elements with two corner points. Results of aerodynamic calculations are presented for the system airfoil-slat that is commonly used as a lift-increasing device. Lift coefficients are calculated for each element and for the system as a whole. V.L.

A87-36088
THREE-DIMENSIONAL HYPERSONIC FLOW OF A DUSTY GAS PAST A WING [O PROSTRANSTVENNOM OBTEKANII KRYLA GIPERZVUKOVYM POTOKOM ZAPYLENNOGO GAZA]
V. N. GOLUBKIN PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Jan.-Feb. 1987, p. 15-20. In Russian. refs

Three-dimensional hypersonic flow of a gas containing solid particles past a low-aspect-ratio wing is investigated analytically using the method of a thin shock layer. The analysis allows for the mutual effect of the solid and gas phases. The corresponding similarity parameters are defined, and the effect of a solid impurity on the pressure distribution over the wing is determined. V.L.

A87-36093
MODELING OF LARGE-SCALE MIXING PROCESSES IN AN EXPANDING SUPERSONIC JET [MODELIROVANIE PROTSESSOV KRUPNOMASSHTABNOGO PEREMESHIVANIIA V RASSHIRIAIUSHCHEISIA SVERKHZVUKOVOI STRUE]
N. A. ZHELTUKHIN and N. M. TEREKHOVA PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Jan.-Feb. 1987, p. 59-65. In Russian. refs

Mass and momentum redistribution in the initial section of an axisymmetric turbulent supersonic jet due to its interaction with natural oscillations of finite amplitude is simulated numerically. The waves produce additional large-scale mixing which may cause the distortion of the mean flow characteristics and, consequently, affect jet noise. Flow distortions can be detected through systematic measurements in different azimuthal planes. V.L.

A87-36336
SURFACE PRESSURE FLUCTUATIONS PRODUCED BY VORTEX SHEDDING FROM A COATED AIRFOIL
M. S. HOWE (Southampton, University, England) Journal of Sound and Vibration (ISSN 0022-460X), vol. 113, March 8, 1987, p. 233-244. refs

The surface pressure fluctuations due to periodic vortex shedding from the blunt trailing edge of a coated airfoil are examined theoretically. The airfoil is modeled by a semiinfinite plate coated with a locally reacting material of uniform mean thickness and set at zero angle of attack to a mean flow of infinitesimal Mach number. The strength of the shed vorticity is determined in terms of the form drag of the airfoil, and the analysis is performed on the basis of linearized thin airfoil theory. A coating of impedance equal to the product of the mean fluid density and the main stream velocity is identified as producing significant and optimal reductions in surface pressure fluctuations relative to those experienced by an uncoated airfoil. It is also deduced that substantially lower levels of aerodynamic sound are generated by the shed vorticity. However, coatings of this type can exhibit serious flutter and/or divergence instabilities, which may increase boundary layer turbulence and flow noise. Modified coating configurations are suggested to overcome this difficulty. Author

A87-36562
UNSTEADY AXISYMMETRIC TURBULENT BOUNDARY LAYER ON A SLENDER BODY OF REVOLUTION
M. KUMARI and G. NATH (Indian Institute of Science, Bangalore, India) Archiwum Mechaniki Stosowanej (ISSN 0373-2029), vol. 38, no. 3, 1986, p. 235-249. refs

The unsteady incompressible turbulent boundary-layer flow over a slender body of revolution has been studied using an eddy-viscosity model for the Reynolds shear stress. The unsteadiness in the flow field is introduced by the free stream velocity which varies with time. The nonlinear partial differential equation with three independent variables governing the flow has been solved numerically using a finite-difference scheme developed by Keller. The free stream velocity is found to exert strong influence on the characteristics of the flow within the boundary layer. The phase angle between wall shear and fluctuating free stream velocity is much smaller than the phase angle between displacement thickness and fluctuating free stream velocity. The skin friction coefficient decreases with the streamwise distance or transverse curvature parameter whereas the Reynolds number increases. The transverse curvature strongly affects the phase angle between wall shear and fluctuating free stream velocity, but its effect on the phase angle between displacement thickness and fluctuating free stream velocity is small. Author

A87-36634
ROTATING STALL AND SURGE AS A COUPLED INSTABILITY IN AXIAL COMPRESSORS - THE COMPUTATION OF UNSTEADY FLOW PROCESSES IN AXIAL-COMPRESSOR DEVICES [ROTIERENDE ABLOESUNG UND PUMPEN ALS GEKOPPELTE INSTABILITAETSFORM IN AXIALVERDICHTERN - EIN BEITRAG ZUR BERECHNUNG INSTATIONAERER STROEMUNGSVORGAENGE IN AXIALVERDICHTERANLAGEN]
KLAUS GRAHL (Bochum, Ruhr-Universitaet, West Germany) and ROLAND FOITZIK (Universitaet Duisburg-Gesamthochschule, West Germany) Forschung im Ingenieurwesen (ISSN 0015-7899), vol. 53, Jan. 1987, p. 1-14. In German. refs

The effects of rotating stall and surge on the unsteady flow in an axial-flow compressor are investigated by means of numerical simulations based on a model comprising an inlet, a single rotor, an outlet, and a throttled plenum chamber. The model treats the compressible flow in two dimensions and takes the rotor loss and deflection correlations and the transfer equations for the plenum chamber into account. The results are presented in extensive tables and graphs and characterized in detail. T.K.

A87-36766
THE JOINT PROGRAM LAMINAR WINGS [GEMEINSCHAFTS-PROGRAMM LAMINARFLUEGEL]
H. KOERNER (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 122-127. In German. refs
(DGLR PAPER 86-124)

An overview is given of joint efforts to achieve laminarization of aircraft wings by the 1990s. Solutions to the problems involving profiling, suction, and cooling are sketched, and the outstanding questions involved are discussed. The state of the art of wing laminarization in Germany and internationally is examined, and the structure and distribution of tasks within the joint effort are shown. C.D.

A87-36788
EXPERIMENTAL RESEARCH ON AN UNDERBODY RAMP INLET UNDER SUPERSONIC FLOW CONDITIONS [EXPERIMENTELLE UNTERSUCHUNGEN AN EINEM UNTERRUMPF-RAMPENEIN-LAUF BEI UEBERSCHALLANSTROEMUNG]
P.-A. MACKRODT (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, West Germany) and D. M. SCHMITZ (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 303-311. In German. refs
(DGLR PAPER 86-142)

An engine inlet with fixed underbody ramp inlet geometry has been developed for use in light fighter aircraft. The design of the inlet, especially that of the system used to divert the boundary layer, is described using theoretical methods and experimental optimization conducted for a finite number of slanted shocks. Results are given for the main flow throughput and the performance parameters and for the influence that the boundary layer diversion system and the Mach number and angle of attack exert on those parameters. C.D.

A87-36790
FINITE VOLUME STEP METHOD FOR INVISCID AND VISCOUS SUPERSONIC FLOWS [FINITE-VOLUMEN-RAUMSCHRITTVERFAHREN FUER REIBUNGSFREIE UND REIBUNGSBEHAFTETE UEBERSCHALLSTROEMUNGEN]
H. RIEGER (Dornier GmbH, Friedrichshafen, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 317-327. In German. refs
(DGLR PAPER 86-162)

Based on finite-volume discretization, volume step procedures for integrating three-dimensional Euler and parabolized Navier-Stokes (NS) equations for inviscid and viscous supersonic flows are developed and presented. An explicit three-dimensional scheme is used to integrate the inviscid Euler equations, and a noniterative implicit method is used to integrate the NS equations. The details of both methods are described and the performance of the methods is illustrated with a few examples. The results are in good agreement with those obtained experimentally and theoretically by other authors. C.D.

A87-36791
SELECTIVE ELIMINATION - A FAST SOLVER FOR REAL-TIME UNSTEADY INTEGRATION OF THE EULER EQUATIONS IN EXPLICIT FORMULATION [SELEKTIVE ELIMINATION - EIN SCHNELLER LOESER ZUR ZEITECHT-INSTATIONAEREN INTEGRATION DER EULER-GLEICHUNGEN IN EXPLIZITER FORMULIERUNG]
R. M. DESLANDES (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 328-334. In German.
(DGLR PAPER 86-163)

It is demonstrated that solutions to Euler equations can be obtained rapidly, and without a substantial increase in algebra, using explicit methods. The conditions and iterative scheme for obtaining these solutions are shown. Examples of the real-time solutions of unsteady Euler equations are given. C.D.

A87-36801
SIMULATION OF VISCOUS FLOWS BY ZONAL SOLUTIONS OF EULER, BOUNDARY-LAYER AND NAVIER-STOKES EQUATIONS
M. A. SCHMATZ (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) DGLR, Jahrestagung, Munich, West Germany, Oct. 8-10, 1986, Paper. 14 p. refs
(MBB-S-PUB-272)

Steady viscous flows are simulated by a zonal concept in which local Navier-Stokes solutions are coupled with solutions of the Euler and boundary-layer equations, with the Navier-Stokes equations being only solved in those flow-field zones where strong interaction occurs. Results for two-dimensional applications are obtained with an alternating coupling scheme. A close coupling scheme using a well suited implicit relaxation scheme for the Euler and the Navier-Stokes equations is introduced for three-dimensional simulations, and computational efficiency is achieved. R.R.

A87-36916#
A COMPUTATIONAL METHOD FOR THREE-DIMENSIONAL FLOW FIELDS OF TRANSONIC TURBINE STAGES AND ITS APPLICATION
ZIKANG JIANG (Qinghua University, Beijing, People's Republic of China) and QIN ZHU (Beijing Heavy Electric Machinery Works, People's Republic of China) Journal of Engineering Thermophysics, vol. 7, Nov. 1986, p. 314-319. In Chinese, with abstract in English. refs

This paper presents a computational method for three-dimensional flow fields of transonic turbine stages, based on the time-marching technique. Making use of the method, the effect of the radial lean-angle of static blades on the reaction of a turbine stage is studied. It is found that when the pressure surfaces of the static blades are declined 10 degrees downward, the reaction distribution along the blades height is improved obviously. This method provides a theoretical basis and a means of numerical simulation for further improving the design of turbine stages. Author

A87-36917#
TRANSONIC FLOW ALONG ARBITRARY STREAM FILAMENT OF REVOLUTION SOLVED BY SEPARATE COMPUTATIONS WITH SHOCK FITTING
BAOGUO WANG, YAONAN HUA, and XIAOYAN HUANG (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Journal of Engineering Thermophysics, vol. 7, Nov. 1986, p. 320-325. In Chinese, with abstract in English. refs

The transonic flow field in a cascade of blades lying on an S1 stream surface of revolution is solved by separate computations in the supersonic and the transonic region. The characteristics method is used to solve the supersonic flow upstream of the passage shock and the direct matrix method is used to solve the transonic flow downstream of the passage shock. The transonic stream-function equation in weak conservative form was obtained, with the passage shock as the inlet boundary line. After discretization of the transonic stream-function equation which was expressed in general nonorthogonal curvilinear coordinates, a set of algebraic equations was obtained. Using the artificial density technique and a new iteration scheme between the stream function and the density, the set was solved by the direct matrix method. Author

A87-36918#
THE CALCULATIONS AND EXPERIMENTS OF AERODYNAMIC CHARACTERISTICS OF THE RADIAL CIRCULAR CASCADES
RUITANG DUN and SHIZHEN SHU (Qinghua University, Beijing, People's Republic of China) Journal of Engineering Thermophysics, vol. 7, Nov. 1986, p. 326-328. In Chinese, with abstract in English.

In this paper, a time-marching method was used to solve the flow field in radial circular cascades. By means of the calculated distribution of velocity on the surface of the blade, the losses of the cascades were calculated with the method of boundary-layer theory. Two cascades were tested in the inward-radial flow wind tunnel. The results of experiments and the calculated data were in acceptable agreement. Therefore, this calculating method could be used in design tasks. Author

A87-36920#
ANALYSIS OF COMPUTATION METHODS IN S2 STREAM SURFACES FOR QUASI-THREE-DIMENSIONAL DESIGN OF TURBINE
YIPING LOU and MANCHU GE (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) Journal of Engineering Thermophysics, vol. 7, Nov. 1986, p. 332-334. In Chinese, with abstract in English.

This paper computed and analyzed four methods which are solving gasdynamic parameters in the S2 stream surfaces and discussed the mathematical solving relationship between the single blade row and monoblade rows. A general computational program has been completed. Examples were computed and results were compared. Two of them are better; the demands of design engineering are satisfied. Author

A87-37104#
TURBULENT BOUNDARY-LAYER PROPERTIES DOWNSTREAM OF THE SHOCK-WAVE/BOUNDARY-LAYER INTERACTION
D. W. KUNTZ (Sandia National Laboratories, Albuquerque, NM), V. A. AMATUCCI, and A. L. ADDY (Illinois, University, Urbana) AIAA Journal (ISSN 0001-1452), vol. 25, May 1987, p. 668-675. Research supported by the University of Illinois. Previously cited in issue 07, p. 833, Accession no. A86-19828. refs
(Contract DAAG29-79-C-0184; DAAG29-83-K-0043)

A87-37105#
NUMERICAL ANALYSIS OF THREE-DIMENSIONAL ELASTIC MEMBRANE WINGS
P. S. JACKSON (Auckland, University, New Zealand) and G. W. CHRISTIE (Systems Science and Research, Auckland, New Zealand) AIAA Journal (ISSN 0001-1452), vol. 25, May 1987, p. 676-682. refs

This paper presents a numerical method for predicting the behavior of an elastic membrane wing under aerodynamic loading. A method for finding the pressure distribution generated by flow over a given three-dimensional surface is combined with another for finding the shape of a given membrane under a given pressure distribution. The pressure is calculated using a vortex lattice simulation of potential flow, and the shape is determined using a finite element representation of the membrane. An iterative scheme is employed to solve the resulting nonlinear equations which relate the shape and loading to the displacements of the surface. A simple example is given, in which the lift and stress distribution are calculated for a membrane wing with the shape and boundary constraints of an idealized hang glider. The method is equally applicable to yacht sails. Author

A87-37107*# Washington Univ., Seattle.
EXPERIMENTS ON SUPERSONIC TURBULENT FLOW DEVELOPMENT IN A SQUARE DUCT
F. B. GESSNER (Washington, University, Seattle), S. D. FERGUSON (Boeing Aerospace Co., Seattle, WA), and C. H. LO (Spectra Technology, Inc., Flow Technology Div., Bellevue, WA) AIAA Journal (ISSN 0001-1452), vol. 25, May 1987, p. 690-697. Previously cited in issue 17, p. 2466, Accession no. A86-38412. refs
(Contract NGR-48-002-141)

A87-37108#
LIFTING SURFACE CALCULATIONS IN THE LAPLACE DOMAIN WITH APPLICATION TO ROOT LOCI
TETSUHIKO UEDA (National Aerospace Laboratory, Chofu, Japan) (Structures, Structural Dynamics and Materials Conference, 27th, San Antonio, TX, May 19-21, 1986, Technical Papers. Part 2, p. 192-200) AIAA Journal (ISSN 0001-1452), vol. 25, May 1987, p. 698-704. Previously cited in issue 18, p. 2604, Accession no. A86-38901. refs

A87-37118#
RAPID COMPUTATION OF UNSTEADY TRANSONIC CASCADE FLOWS
DAVID NIXON, KEH-LIH TZUOO, and ALFRED AYOUB (Nielsen Engineering and Research, Inc., Mountain View, CA) AIAA Journal (ISSN 0001-1452), vol. 25, May 1987, p. 760-762. refs
(Contract N00014-83-C-0435)

Nixon's (1983) method for the computation of unsteady flow through a cascade for an interblade phase angle, using only one set of computational data, is presently extended by a technique allowing the inclusion of a large number of blades in the calculation without incurring an onerous computational requirement. The extended method is applied to the case of an unstaggered cascade. It is shown that resonance can occur for an infinite cascade, and that there is a significant difference between subsonic and transonic flows. O.C.

A87-37204#
UNSTEADY AERODYNAMICS IN ROTARY-WING AEROELASTICITY - A REVIEW
C. VENKATESAN and V. T. NAGARAJ (Hindustan Aeronautics, Ltd., Helicopter Design Bureau, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Nov.-Dec. 1986, p. 229-239. refs

It is well known that unsteady aerodynamics plays an important role in the aeroelastic stability and response of both rotary-wing and fixed-wing vehicles. A wide array of mathematical models have been developed to represent unsteady aerodynamics, starting from simple and computationally efficient models and culminating in computationally expensive models. This paper presents the various unsteady aerodynamic models which are widely used in rotary-wing aeroelastic analysis and also their limitations. Finally, recent developments in finite state modeling of unsteady aerodynamics and their wide applicability are presented. Author

A87-37205#
COMPUTATIONS WITH 3-D EULER CODE FOR WINGS
N. R. SUBRAMANIAN and S. R. SIDDALINGAPPA (National Aeronautical Laboratory, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Nov.-Dec. 1986, p. 241-248. refs

The solution of time-dependent Euler equations for wings using an explicit Runge-Kutta time-marching finite volume procedure by employing a combination of second- and fourth-order dissipation, variable-time step, and enthalpy damping to speed up the convergence to steady state is described. The wing flow fields for an ONERA-M6 wing and an arrow wing are computed utilizing the modular SS-NAL-07 Euler code, which contains a mesh generator and a flow solver. Grid sizes for the wings are solved and presented. It is determined that the Euler code provides good calculations of the flow over the wing; however, more accurate results are possible by increasing the grid cells. I.F.

A87-37209#
A SYNTHESIS OF PROCEDURES FOR SELECTING THE GEOMETRIC FEATURES OF AN AIR INTAKE - FOR M = 0 TO 1.8
R. JOLLY (Hindustan Aeronautics, Ltd., Aircraft Design Bureau, Bangalore, India), K. SUDHAKAR (Indian Institute of Technology, Bombay, India), and K. A. DAMODARAN (Indian Institute of Technology, Madras, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Nov.-Dec. 1986, p. 277-282. refs

Intake internal performance and intake drag are the primary considerations in the selection of its configuration and geometry. Empirical analysis procedures from various sources are put together to be used as a design tool in estimating intake total pressure recovery and spillage drag and for establishing a criteria for buzz free operation of the intake. A computer code has been made with modular features that makes it possible to update any of the estimation procedures should a more reliable source become available. This code has been applied to a configuration for which a data base exists for validation. The analysis procedures can be gainfully used in design studies of intakes, for example, trade-off studies for selection of intake geometric features. A typical trade-off for selecting the ramp angle to minimize supersonic acceleration time is presented. Author

A87-37210#
NORMAL FORCE AND PITCHING MOMENT ON BODY-INTAKE CONFIGURATION IN SUPERSONIC FLOWS
P. THEERTHAMALAI, S. PANNERSELVAM, and N. BALACHANDRAN (Defence Research and Development Laboratory, Hyderabad, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Nov.-Dec. 1986, p. 283-288. refs

A theoretical prediction method has been developed for the estimation of normal force and pitching moment on body-intake configuration with full mass flow through intakes. Superposition of the linear and the nonlinear contribution has been assumed for the over all characteristics. Woodwards Panel Method has been used for the prediction of linear contribution and cross flow method has been employed for the nonlinear effects. The results have been compared with experimental data on (1) side mounted twin intake configuration, (2) bottom mounted single intake configuration. Theoretical and experimental values on a typical strap-on-booster-body configuration have also been compared. A favorable comparison with the experimental values have been noticed. Author

A87-37211#
NUMERICAL SIMULATION OF AN INVISCID SUPERSONIC FLOW PAST A SPHERE BY A SELF ADJUSTING HYBRID SCHEME FOR SHOCK CAPTURING
K. P. SINGH (Indian Space Research Organization, Vikram Sarabhai Space Centre, Trivandrum, India), S. K. GOYAL, and P. NIYOGI (Indian Institute of Technology, Kharagpur, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Nov.-Dec. 1986, p. 289-294. refs

An inviscid supersonic flow is simulated over a sphere by a 'self-adjusting hybrid scheme for shock capturing'. This scheme, which uses a modified Shuman filter, adjusts automatically to a second-order scheme in the smooth region and changes to the first-order scheme in the narrow shock region. Bow shock is captured by mesh not aligned with the shock. The present results of the pressure distribution and the captured shock shape at free-stream Mach numbers from 1.3 to 8.0 compare well with other theoretical results. Despite the first-order scheme in the shock region, the shocks are smeared over two to four mesh intervals only. The modified Shuman filter required no tuning for Mach numbers less than or equal to 5.5. Author

A87-37213#
3 D WING ANALYSIS USING A LOW ORDER PANEL METHOD
K. SUDHAKAR, S. P. KORUTHU, and G. R. SHEVARE (Indian Institute of Technology, Bombay, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Nov.-Dec. 1986, p. 303-306. refs

A panel method code for subcritical flow analysis of complete aircraft configurations is under development. The code can presently analyze three-dimensional wings. A simple tapered wing and a strake wing have been analyzed, and the results have been compared with the higher order datum solutions of Roberts. The agreement is excellent. The code has great potential for local flow analysis with minimum demands on computer memory. Author

A87-37554#
TRANSONIC FLOW FIELD ANALYSIS FOR REAL FUSELAGE CONFIGURATIONS
ZHAOQIAN WANG (Shengyang Aircraft Co., People's Republic of China) Acta Aerodynamica Sinica (ISSN 0258-1825), vol. 5, March 1987, p. 31-37. In Chinese, with abstract in English. refs

The modified small-disturbance (MSD) equation is used in this paper. It is solved by a relaxed-line method. Crude and fine grid systems are used alternatively in the solving process. Engquist-Osher and Jameson difference schemes are combined, and the lateral relaxed-line method is used at local lines of the fuselage side. Faster convergence is obtained in a numerical experiment using this method. Several examples prove that fewer interactions are required, and that computing results agree with experimental results quite well. Author

A87-37839#
A METHOD FOR COMPRESSOR AXISYMMETRIC CHARACTERISTICS BY THE AID OF ROTATING STALL PARAMETERS
GUOCAI TANG and HUIMIN ZHANG (Nanjing Aeronautical Intitute, People's Republic of China) Journal of Aerospace Power, vol. 2, Jan. 1987, p. 39-44, 91. In Chinese, with abstract in English. refs

A new method is provided for obtaining the axisymmetric characteristics of an axial compressor using its rotating stall parameters. The principal difference of the method from the method of Koff and Greitzer (KG) is its utilization of nonuniformity along circumferential direction induced by rotating stall with the inertial correction incorporated to gain the axisymmetric characteristics in the flow range in which the rotating stall usually occurs. The characteristics of a typical example follow a quite reasonable trend. This method exhibits a wider applicable range because it is not restrained by the requirements for the three time scales as specified in KG's method and also due to the fact that the stall parameters are easier to be acquired than the surge parameters. Author

A87-37849#
A CALCULATION METHOD OF DETERMINING BLADE SECTION DRAG IN A ROTOR BASED ON WAKE MEASUREMENTS
YUZONG WANG (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power, vol. 2, Jan. 1987, p. 81-83, 96. In Chinese, with abstract in English.

A calculation method is proposed to determine the blade section drag instead of doing a sophisticated experimental measurement of it. It is possible to obtain the detailed distributions of velocity and pressure on the boundary line from the wake measurements behind a compressor rotor. By using these distributions, the blade section drag is determined by means of the momentum equation of integral representation and appropriate mathematical manipulation. Author

A87-37856#
A STUDY ON THE ROTATING STALL IN VANELESS DIFFUSERS OF CENTRIFUGAL FANS. I - ROTATIONAL SPEEDS OF STALL CELLS, CRITICAL INLET FLOW ANGLE
HIROMU TSURUSAKI (Osaka University, Toyonaka, Japan), KENSAKU IMAICHI (Osaka Hoki, Ltd., Japan), and RYO MIYAKE (Hitachi, Ltd., Mechanical Engineering Research Laboratory, Tsuchiura, Japan) JSME International Journal (ISSN 0913-185X), vol. 30, Feb. 1987, p. 279-287. refs

The rotational speeds of stall cells in vaneless diffusers and critical inlet flow angles for rotating stalls under the conditin of no scroll were studied experimentally. Two experimental equations for rotational speeds are derived and a prediction method is presented. The predicted rotational speeds agree well with measured values in the literature. A simple equation for the critical inlet flow angle is derived from the experimental data. This equation is useful for predicting the onset of a rotating stall. In the experiment, a weak velocity fluctuation was found at the position of reverse flow on the diffuser wall just before the rotating stall. It is concluded that reverse flow is the cause of rotating stall in a vaneless diffuser. The conditions of reverse flow layers on the diffuser wall just before a rotating stall are made clear by a numerical analysis. The properties of a fully developed rotating stall are also presented. Author

A87-38038#
EXPERIMENTAL STUDY OF THE BOUNDARY LAYER ON A WING PROFILE BY PRESSURE PROBES, HOT-WIRE ANEMOMETRY, AND LASER ANEMOMETRY, AND COMPARISON WITH CALCULATION RESULTS [ETUDE EXPERIMENTALE DE LA COUCHE LIMITE SUR UN PROFILE D'AILE PAR SONDES DE PRESSION, ANEMOMETRIE A FIL CHAUD ET ANEMOMETRIE LASER ET COMPARAISON AVEC DES RESULTATS DE CALCUL]
B. C. JAEGGY, R. KAUFFMANN, G. KOERBER (Saint-Louis, Institut Franco-Allemand de Recherches, France), R. KIOCK, R. RADESPIEL (DFVLR, Institut fuer Entwurfsaerodynamik, Brunswick, West Germany) et al. Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 23rd, Modane, France, Nov. 12-14, 1986. 52 p. In French. refs
(AAAF PAPER 86-15)

Subsonic wind tunnel measurements of the boundary layer of an NACA 65213 profile are obtained by three methods: a double-pressure probe (measuring static and stagnation pressure), a hot-wire anemometer, and a two-dimensional laser anemometer. A velocity component, the corresponding fluctuations, the second component, its fluctuations, and the Reynolds tension are obtained from the measurements. From the resulting velocity profiles, the usual integral quantities are derived. Good agreement is found between experimental results and results obtained using the GENMIX algorithm of Spaulding (1977). R.R.

A87-38042#
STUDY OF THE AERODYNAMIC FIELD OF A HELICOPTER ROTOR IN HOVER - COMPARISON BETWEEN THEORY AND EXPERIMENT [ETUDE DU CHAMP AERODYNAMIQUE D'UN ROTOR D'HELICOPTERE EN VOL STATIONNAIRE - COMPARAISON THEORIE/EXPERIENCE]
D. FAVIER, M. NSI MBA (Aix-Marseille II, Universite, Marseille, France), and A. VUILLET (Aerospatiale, Marignane, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 23rd, Modane, France, Nov. 12-14, 1986. 33 p. In French. refs
(AAAF PAPER NT 86-19)

The range of validity of two aerodynamic rotor calculation methods is investigated by comparison with experiments which are performed in the hovering case to evaluate the rotor performance, bounded circulation on the blade, tip vortex paths, induced velocity field, and influence of the evolutive blade tip geometry. Comparison is made using data from five rotors with different blade profiles. The first model uses classical momentum theory (the method of rings). In the second method, vortex theory is used in a free wake analysis procedure which is based on an initial prescribed blade circulation. R.R.

A87-38044#
VALIDATION OF AERODYNAMIC MODELS FOR PREDICTING THE AEROELASTIC BEHAVIOR OF AIRCRAFT WITH EXTERIOR STORES [VALIDATION DES MODELES AERODYNAMIQUES POUR LA PREVISION DU COMPORTEMENT AEROELASTIQUE DES AVIONS AVEC CHARGES EXTERIEURES]
MURIELLE MAINARD, A. LABUSSIERE, and A. LAURENT (Avions Marcel Dassault Breguet Aviation, Saint-Cloud, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 23rd, Modane, France, Nov. 12-14, 1986. 46 p. In French. refs
(AAAF PAPER NT-86-21)

The effects of external stores on the flutter behavior of combat aircraft are investigated analytically and experimentally. Wind-tunnel tests on quasi-rigid models are employed to validate the predictions of computer programs developed by Laurent (1975) and Labussiere and Brevan (1985) on the basis of small-perturbation theory: TOPSUB (subsonic), TOPSUP (supersonic), and DELTATRANS (transonic delta-wing). The theoretical bases of the programs are explained, and the advantages of various test procedures are discussed. Predicted and measured results for an F1 wing with bracket and tank; an F1 half-wing with tip-mounted Magic air-to-air missile; a half-model with wing, canard, fuselage, and tip-mounted Magic; and (as baseline) an F1 NORA wing alone are compared in extensive graphs and diagrams. T.K.

A87-38045#
HIGH-LIFT - THEORETICAL AND EXPERIMENTAL PROBLEMS [HYPERSUSTENTATION - PROBLEMES THEORIQUES ET EXPERIMENTAUX]
P. CAPBERN (Aerospatiale, Division Avions, Paris, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 23rd, Modane, France, Nov. 12-14, 1986. 44 p. In French. refs
(AAAF PAPER NT 86-22)

Problems in the evaluation of the drag and maximum-lift coefficients in high-lift systems are examined for the case of a system with simple-slot or double-slot flaps. The validation of wind tunnel measurements of drag using wake sounding is first discussed, and factors including the adjustment of the probe and its sensitivity to turbulence are considered. Experimental results are then used to validate the ONERA coupling method for the multiprofile calculation of incompressible two-dimensional flows. Results suggest that modeling improvements are necessary in the predictions of stall and drag. R.R.

A87-38493#
A VERTEX BASED MULTIGRID ALGORITHM FOR THREE DIMENSIONAL COMPRESSIBLE FLOW CALCULATIONS
A. JAMESON (Princeton University, NJ) IN: Numerical methods for compressible flows - Finite difference, element and volume techniques; Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 45-73. refs

A new multigrid method for the solution of the inviscid compressible flow equations is presented. The algorithm uses a finite volume formulation with the flow variables stored at the cell vertices, and a multistage time stepping scheme augmented by residual averaging. In calculations of transonic flow past a swept wing the method exhibits remarkably fast convergence. Author

A87-39079#
UNIFIED MODEL FOR THE CALCULATION OF BLADE PROFILE LOSSES OF AXIAL COMPRESSORS [MODELE UNIFIE DE CALCUL DES PERTES DE PROFIL DES AUBAGES DES COMPRESSEURS AXIAUX]
B. STERGIOPOULOS and G. TZIMOPOULOS (Salonika, University, Greece) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 31, Nov.-Dec. 1986, p. 603-611. In French. refs

A mathematical model for the calculation of blade profile losses of axial compressors is presented which takes into account the limiting case of zero diffusion, making possible the consideration of various geometrical and aerodynamic effects. A quasi-one-dimensional approximation is used, assuming that the flow properties can be described in terms of the average values obtained at each cross section of the passage. It is assumed that the flow is adiabatic and that the fluid behaves as a perfect gas. The model is validated by comparison with previous experimental results obtained for industrial compressors and for NASA's multistage axial compressors. R.R.

A87-39147#
SHOCK-INDUCED SEPARATED FLOWS ON THE LEE SURFACE OF DELTA WINGS
S. N. SESHADRI and K. Y. NARAYAN (National Aeronautical Laboratory, Bangalore, India) Aeronautical Journal (ISSN 0001-9240), vol. 91, March 1987, p. 128-141. refs

Experiments were conducted to study shock-induced separated flows on the lee surface of delta wings with sharp leading edge at supersonic speeds. Two sets of delta wings of different thickness (10 and 25 deg normal angle), each with leading edge sweep angles varying from 45 to 70 deg, were tested. The measurements over a Mach number range from 1.4 to 3.0, included oil flow visualizations and static pressure distributions (on the thicker wings only). Features of shock-induced separated flows, including the boundary between this type of flow and fully attached flow, have been determined. Results indicate that this boundary does not show any significant dependence on wing thickness within the limit of thicknesses tested. It is shown that this boundary can be predicted for thin delta wings using a well known criterion for incipient separation in a glancing shock wave boundary layer interaction; a pressure rise of 1.5 is required across the shock. Author

A87-39218#
MOTION OF A HIGH-LIFT WING IN SUPERSONIC FLOW [DVIZHENIE MEKHANIZIROVANNOGO KRYLA V SVERKHZVUKOVOM POTOKE]
B. A. ERSHOV Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), Oct. 1986, p. 14-16. In Russian.

For a high-lift wing of infinite span moving with a constant supersonic velocity, calculations are made of the lifting force, pitching moment, and hinge moments. The approach used here is based on a linear model of a thin wing and on a model of a high-lift wing whose median line consists of n hinged stiff links. Calculation results are presented for arbitrary motions of the wing elements. V.L.

N87-21850# Dayton Univ., Ohio.
THE INTEGRAL EQUATION FOR THE TIME DEPENDENT LINEARIZED POTENTIAL FLOW OVER A WING Interim Report, Jul. 1985 - Aug. 1986
KARL G. GUDERLEY and MAXWELL BLAIR Dec. 1986 80 p
(Contract F33615-86-C-3200)
(AD-A176684; AFWAL-TR-86-C-3200) Avail: NTIS HC A05/MF A01 CSCL 01B

This report derives the integral equation for the linearized potential flow over a planar wing which may undergo time dependent deformations. Rigid body motions of the wing are of course included. The final goal is the determination of the time dependent pressure distribution. This report is, however, restricted to the derivation of the formulas necessary for this purpose. For the problem at hand fundamental solutions are available which obviates the need to solve the underlying partial differential equation. The potential is expressed by a distribution of time dependent doublets, initially unknown, over the planform and its wake. The integral equation arises, in principle, by equating the upwash at the wing due to this doublet distribution with the values derived from the wing deformation. The kernel of this integral equation contains singularities which make this formulation unsuitable for numerical work. This report removes this impediment. GRA

N87-21851# Poseidon Research, Irvine, Calif.
RESEARCH ON POST-STALL AERODYNAMICS Final Research Report, Aug. 1984 - Sep. 1986
R. B. MYERS, Z. T. NGUYEN, and S. C. CROW Nov. 1986 100 p
(Contract F49620-84-C-0084)
(AD-A177107; RR-83; AFOSR-87-0014TR) Avail: NTIS HC A05/MF A01 CSCL 20D

Fundamental results for two and three dimensional unsteady flows are derived. A model for vortex shedding at salient edges is advanced. A two dimensional Euler solver implementing this vortex shedding mechanism is described. Results of applying this model to impulsively started flat plates with fixed and with oscillating chord at angle of attack are presented. Implications for manipulation of the vortex wake in a post stall maneuver are discussed. A three dimensional unsteady Euler solver based on primitive variables is described. Results of three dimensional computations for delta wing at fixed and time varying angle of attack are presented. GRA

N87-21855*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WIND-TUNNEL FREE-FLIGHT INVESTIGATIN OF A 0.15-SCALE MODEL OF THE F-106B AIRPLANE WITH VORTEX FLAPS
LONG P. YIP May 1987 46 p
(NASA-TP-2700; L-16202; NAS 1.60:2700) Avail: NTIS HC A03/MF A01 CSCL 01A

An investigation to determine the effects of vortex flaps on the flight dynamic characteristics of the F-106B in the area of low-speed, high-angle-of-attack flight was undertaken on a 0.15-scale model of the airplane in the Langley 30- by 60-Foot Tunnel. Static force tests, dynamic forced-oscillation tests, as well as free-flight tests were conducted to obtain a data base on the flight characteristics of the F-106B airplane with vortex flaps. Vortex flap configurations tested included a full-span gothic flap, a full-span constant-chord flap, and a part-span gothic flap. Author

N87-21856 Princeton Univ., N. J.
COMPUTATIONAL STUDIES IN LOW SPEED ROTOR AERODYNAMICS Ph.D. Thesis
TODD RANDALL QUACKENBUSH 1987 211 p
Avail: Univ. Microfilms Order No. DA8702166

Some issues have been addressed by development of curved vortex segments for use in free wake models. These curved elements are assumed to have a parabolic geometry and are fitted to vortex filaments to replace straight elements traditionally used. Substitution allows distorted filaments to be modelled with substantially fewer curved arcs than straight segments. Resulting improvement in computational efficiency is accompanied by more accurate prediction of the local velocity field of vortex. Extensive computational tests were carried out to illustrate improved performance of curved elements. New curved elements have been incorporated into a fullfree wake model suitable for analyzing low-speed rotor behavior. Primary application of this simulation has been prediction of rotor blade flapping motion and associated hub moments at low forward speed (mu less than 0.1 to 0.15). Preliminary validation of code was performed by correlating flapping data from wind tunnel tests of an articulated model rotor. The role of distorted rotor wake in augmenting downwash over the aft portion of rotor disk is analyzed and discussed. Augmentation of downwash is shown to be a key factor in driving the lateral flapping response of rotor. Predictions are made of rotor lateral flapping response in climb and descent, regimes not previous simulated with free wake models. Simulation is also shown to be capable of predicting hub moment response of hingeless model rotor to cyclic and collective inputs at advance ratio .05. Effects of rotor thrust, advance ratio, and climb rate on wake convergence are explored and illustrated. Dissert. Abstr.

N87-21857# Notre Dame Univ., Ind.
THE PREDICTION OF TRANSITIONAL SEPARATION BUBBLES AT LOW REYNOLDS NUMBERS Ph.D. Thesis
GORDON S. SCHMIDT 1986 194 p
Avail: Univ. Microfilms Order No. DA8702971

In order to predict the aerodynamic characteristics of an airfoil, the boundary layer development along its surface must be accurately determined. Several approaches for predicting the characteristics of separation bubbles were reviewed. These included empirical relationships, numerical solutions of the boundary layer equations, and semi-empirical methods. The latter techniques are particularly attractive because they are simple and yet are based on theory, being solutions to the integral forms of the boundary layer equations. However, their success depends on empirically-founded relationships. The object of the present research was to test these relationships at low Reynolds numbers and to propose new ones if necessary. This was accomplished by analyzing measurements of separation bubbles formed on an NACA 66 sub 3-018 airfoil at chord Reynolds numbers ranging from 500,000 to 200,000. The data studied consisted of velocity profiles obtained in the vicinity of the separation bubbles as well as flow visualization and surface pressure measurements. Analysis of the data revealed a significant Reynolds number influence on the evolution of laminar separated flow. Dissert. Abstr.

N87-21861# National Aeronautical Lab., Bangalore (India). Aerodynamics Div.
BUFFET ONSET MEASUREMENTS ON AN AIRCRAFT MODEL AT TRANSONIC MACH NUMBERS
P. R. VISWANATH Apr. 1986 39 p
(NAL-TM-AE-8602) Avail: NTIS HC A03/MF A01

Buffet onset measurements were performed on a low aspect ratio, moderately swept, aircraft model at three transonic Mach numbers in the 1.2 m tunnel. Instrumentation included wing root strain gauges, a wing tip accelerometer, wing trailing edge pressure taps, and standard six component internal strain gauge balance. Results of buffet onset obtained by these different techniques are compared. A discussion of the buffet onset results, as it relates to the main features of the flow on the wing upper surface, is also included. Author

N87-21862# National Aeronautical Lab., Bangalore (India). Fluid Mechanics Div.
ON 3D BOUNDARY LAYER COMPUTATIONS ON SWEPT WINGS
N. R. SUBRAMANIAN and M. I. JAMES May 1987 26 p
(NAL-PD-FM-8715) Avail: NTIS HC A03/MF A01

A three-dimensional turbulent boundary layer code based on an integral method developed by Cousteix and Aupoix has been made operational on the NAL computer. The turbulent modeling is based on an improved mixing length hypothesis and similarity solutions. This code is developed for a general coordinate system

for flows up to Mach number 4 on an adiabatic wall. Two test cases (NLR supercritical wing and ONERA-M6 wing) have been tested using this program. Results for the NLR wing have been compared with the available computer results. Author

N87-21863# National Aeronautical Lab., Bangalore (India). Aerodynamics Div.
ANALYSIS OF TWO-DIMENSIONAL MULTI-COMPONENT AIRFOILS IN VISCOUS FLOWS
H. N. V. DUTT Jan. 1987 127 p
(NAL-TM-AE-8701) Avail: NTIS HC A07/MF A01

A method and computer program for analysis of multicomponent airfoils in subsonic, viscous, attached flows are described. The problem is divided into a number of primary task areas, each requiring mathematical modeling and one or more subroutines along with the necessary interfacing logic for digital computation. These are: geometry definition and geometry preprocessing; inviscid analysis; boundary layer solution; combined solution; and determination of overall loads and moments. The inviscid solution is based on an efficient vortex singularity method. The boundary layer solution is comprised of laminar, transition, and turbulent boundary layers in subsonic flow. The combined solution is computed iteratively using the concept of displacement flux by Preston. The overall loads and moments are computed by integrating the pressures. The code was validated against a number of cases to bring out its capabilities and deficiencies. The results of the study indicate that the multi-element program can provide a valuable insight into a number of areas of high lift airfoil design. Author

N87-21864# National Aeronautical Lab., Bangalore (India). Aerodynamics Div.
LEE SURFACE FLOW OVER DELTA WINGS AT SUPERSONIC SPEEDS: SOME FEATURES OF DIFFERENT TYPES OF FLOW
S. N. SESHADRI and K. Y. NARAYAN Dec. 1986 39 p
(NAL-TM-AE-8612) Avail: NTIS HC A03/MF A01

The features of the different types of flow on the lee surface of delta wings at supersonic speeds were studied in terms of the location of separation and re-attachment lines and shock waves and their variation with Mach number, sweep back, thickness, and angle of attack. The study is largely based on tests on two sets of flat topped delta wing models having sweep back angles of 45, 50, 60, and 70 degrees at freestream Mach numbers of 1.6, 1.8, 2.0, 2.5, and 3.0. The first set of models had a wedge angle normal to the leading edge of 10 degrees while the second set had a wedge angle of 25 degrees. In addition, a 60 degree sweepback delta wing with a wedge angle of 40 degrees was also tested. The results indicate that in the leading edge separated flow region, the location of attachment and secondary separation lines and their variation with the angle of attack depended on the particular type of flow. In the attached leading edge flow region, however, the location of the shock-induced separation line is independent of the particular type of flow. Within each type of flow, the effects of thickness are in general found to be small. Author

N87-21865# National Aeronautical Lab., Bangalore (India). Aerodynamics Div.
LEE-SURFACE FLOW OVER DELTA WINGS AT SUPERSONIC SPEEDS
S. N. SESHADRI and K. Y. NARAYAN Sep. 1986 136 p
(NAL-TM-AE-8610) Avail: NTIS HC A07/MF A01

Experiments were conducted to study the types of flow that occur on the lee surface of delta wings at supersonic speeds. Two sets of flat topped delta wings of different thickness, each with leading edge sweep angles of 45, 50, 60, and 70 degrees, were tested. The measurements, performed at Mach numbers of 1.4, 1.6, 1.8, 2.0, 2.5, and 3.0, included oil flow visualization and static pressure distributions. From these and other existing measurements, the leeside flows were classified into nine distinct types. These types of flows were displayed in a plane of Mach number and angle of attack normal to the leading edge. The experimental results indicate that increasing wing thickness has no qualitative effect on the types of flow observed but does shift the boundaries between some of the types of flow. The extensive static pressure data obtained has made it possible to identify each type of flow with a characteristic pressure distribution. The development of the flow as it changes from a leading edge separated type to an attached flow and vice versa was discussed based on the pressure distributions. Author

N87-21866# National Aeronautical Lab., Bangalore (India). Aerodynamics Div.
NONPLANAR VORTEX LATTICE METHOD FOR ANALYSIS OF COMPLEX MULTIPLE LIFTING SURFACES
B. RAJESWARI and H. N. V. DUTT Aug. 1986 47 p
(NAL-TM-AE-8606) Avail: NTIS HC A03/MF A01

A method for determining the aerodynamic characteristics of complex multiple lifting surfaces in inviscid subcritical flows was developed and programmed on a UNIVAC 1100/60 computer. Each lifting surface is represented by a network of nonplanar horse shoe vortices distributed on the mean surface and trailing to infinity. The strengths of these vortices are determined by requiring the flow to be parallel to the surface at a number of control points. The force due to a vortex segment is calculated as the vector product of local velocity and the vortex strength multiplied by density. The program can handle wings with breaks and spanwise segmented flaps in leading and trailing edges, local dihedral, camber, and twist. The code can be used to compute lift, induced drag, and pitching moments for any lifting planar or nonplanar surfaces and surfaces in combination like wing-canard or wing-horizontal tail. The program was validated for a number of configurations for which experimental data is available. Author

N87-21867# National Aerospace Lab., Tokyo (Japan). STOL Aircraft Project Group.
PRESSURE MEASUREMENT AROUND THE AFT BODY OF THE NAL STOL-RESEARCH-AIRCRAFT MODEL
1986 18 p In JAPANESE; ENGLISH summary
(NAL-TR-919; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

The pressure measurements around the aft body of the NAL STOL Research Aircraft model were carried out in order to explicate the aerodynamic interference between the jet engine exhaust flow and the aft body. Experimental data are useful to comprehend quantitatively the contribution of the aft body to the pressure profile, side force and yawing moment when all engines are operative or an inner engine is inoperative. From the comparison with force tests conducted previously, this quantitative contribution to the whole body was made clear. Author

N87-21868# National Aerospace Lab., Tokyo (Japan).
NUMERICAL ANALYSIS OF INVISCID COMPRESSIBLE FLOWS ABOUT WING-FUSELAGE COMBINATIONS BASED ON THE EULER EQUATIONS
TOMIKO ISHIGURO, SATORU OGAWA, and KEIKO OGUCHI May 1986 15 p
(NAL-TR-896T; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

A numerical procedure based on the Euler equations for analyzing the compressible inviscid transonic flow about a wing-fuselage combination is presented in this paper. In order to treat precisely boundary conditions on the combinational surface and at infinity, the exterior of the wing-fuselage combination in physical space is mapped into a rectangular parallelepiped in a computational space and then a uniform grid is generated there. The Euler equations are solved by the finite volume method using the Runge-Kutta type scheme of the second order accuracy and the local time step technique. Three examples are presented to show the utility of the numerical procedure. Numerical results obtained by the procedure are compared with experimental results and numerical results by the NAL utility code YOKUDO-P based on the full potential equation, and it is shown that the obtained results are in good agreement with the experimental data. Author

N87-21869# National Aerospace Lab., Tokyo (Japan).
COMPARISON OF TRANSONIC AIRFOIL CHARACTERISTICS BY NAVIER-STOKES COMPUTATION AND BY WIND TUNNEL TEST AT HIGH REYNOLDS NUMBER
NAOKI HIROSE, NOBUHIRO KAWAI, and JUN ICHI MIYAKAWA Sep. 1986 17 p
(NAL-TR-911T; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

The two-dimensional Navier-Stokes code, NSFOIL, is validated in terms of analysis of practical transonic advanced technology airfoil compared to data obtained from wind-tunnel tests. The comparison is carried out at a high Reynolds number of 23 million which corresponds to the actual flight conditions of a transonic transport aircraft. The numerical data show satisfactory agreement in both aerodynamic forces and pressure coefficients, so the code is concluded to be a very effective tool for predicting nonlinear characteristics of transonic airfoils, which has not been possible with any existing inviscid code. In the course of careful comparison, some future improvements of the code are probed in order to obtain even better simulation with this promising computer code. Author

N87-21871*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
NEW METHODS AND RESULTS FOR QUANTIFICATION OF LIGHTNING-AIRCRAFT ELECTRODYNAMICS
FELIX L. PITTS, LARRY D. LEE, RODNEY A. PERALA, and TERENCE H. RUDOLPH (Electro Magnetic Applications, Inc., Lakewood, Colo.) Jun. 1987 67 p
(NASA-TP-2737; L-16281; NAS 1.60:2737) Avail: NTIS HC A04/MF A01 CSCL 01A

The NASA F-106 collected data on the rates of change of electromagnetic parameters on the aircraft surface during over 700 direct lightning strikes while penetrating thunderstorms at altitudes from 15,000 t0 40,000 ft (4,570 to 12,190 m). These in situ measurements provided the basis for the first statistical quantification of the lightning electromagnetic threat to aircraft appropriate for determining indirect lightning effects on aircraft. These data are used to update previous lightning criteria and standards developed over the years from ground-based measurements. The proposed standards will be the first which reflect actual aircraft responses measured at flight altitudes. Nonparametric maximum likelihood estimates of the distribution of the peak electromagnetic rates of change for consideration in the new standards are obtained based on peak recorder data for multiple-strike flights. The linear and nonlinear modeling techniques developed provide means to interpret and understand the direct-strike electromagnetic data acquired on the F-106. The reasonable results obtained with the models, compared with measured responses, provide increased confidence that the models may be credibly applied to other aircraft. Author

N87-21872# National Aerospace Lab., Tokyo (Japan).
A CURVILINEAR COORDINATE THIN-LAYER NAVIER-STOKES HYBRID SCHEME FOR TRANSONIC AIRFOIL ANALYSIS
NAOKI HIROSE, KEN-ICHI MATSUNO, KOJI KOMATSU, and MAKOTO FUJITA 1986 44 p In JAPANESE; ENGLISH summary
(NAL-TR-913; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

A new procedure of hybrid finite difference scheme for the two-dimensional thin-layer Navier-Stokes equations in body-fitted curvilinear coordinates is proposed. The present procedure utilizes a time and space splitting scheme which is a hybrid scheme composed of explicit and implicit schemes. MacCormack's explicit predictor-corrector scheme is applied to the flow direction. The predictor-corrector type Crank-Nicholson scheme originally developed for the boundary layer equations by Matsuno is extended to the Navier-Stokes equations and applied to the directional normal to the body surface and the boundary layer. Some numerical computations were made for a supersonic laminar boundary layer problem on a semi-infinite flat plate and for a parabolic arc airfoil problem in transonic flow. Comparison of the results with the other numerical code, NSFOIL, shows favorable agreements although some improvement in computational efficiency still remains. Author

N87-21873*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECTS OF AFTERBODY BOATTAIL DESIGN AND EMPENNAGE ARRANGEMENT ON AEROPROPULSIVE CHARACTERISTICS OF A TWIN-ENGINE FIGHTER MODEL AT TRANSONIC SPEEDS
LINDA S. BANGERT, LAURENCE D. LEAVITT, and DAVID E. REUBUSH Jun. 1987 134 p
(NASA-TP-2704; L-16227; NAS 1.60:2704) Avail: NTIS HC A07/MF A01 CSCL 01A

The effects of empennage arrangement and afterbody boattail design of nonaxisymmetric nozzles on the aeropropulsive characteristics of a twin-engine fighter-type model have been determined in an investigation conducted in the Langley 16-Foot Transonic Tunnel. Three nonaxisymmetric and one twin axisymmetric convergent-divergent nozzle configurations were tested with three different tail arrangements: a two-tail V-shaped arrangement; a staggered, conventional three-tail arrangement; and a four-tail arrangement similar to that on the F-18. Two of the nonaxisymmetric nozzles were also vectorable. Tests were conducted at Mach numbers from 0.60 to 1.20 over an angle-of-attack range from -3 deg to 9 deg. Nozzle pressure ratio was varied from 1 (jet off) to approximately 12, depending on Mach number. Results indicate that at design nozzle pressure ratio, the medium aspect ratio nozzle (with equal boattail angles on the nozzle sidewalls and upper and lower flaps) had the lowest zero angle of attack drag of the nonaxisymmetric nozzles for all tail configurations at subsonic Mach numbers. The drag levels of the twin axisymmetric nozzles were competitive with those of the medium-aspect-ratio nozzle at subsonic Mach number. Author

N87-21874*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTATIONAL METHODS FOR UNSTEADY TRANSONIC FLOWS
JOHN W. EDWARDS and J. L. THOMAS Mar. 1987 31 p Presented at the AIAA 25th Aerospace Sciences Meeting, 12-15 Jan. 1987, Reno, Nev.
(NASA-TM-89106; NAS 1.15:89106; AIAA-87-0107) Avail: NTIS HC A03/MF A01 CSCL 01A

Computational methods for unsteady transonic flows are surveyed with emphasis on prediction. Computational difficulty is discussed with respect to type of unsteady flow; attached, mixed (attached/separated) and separated. Significant early computations of shock motions, aileron buzz and periodic oscillations are discussed. The maturation of computational methods towards the capability of treating complete vehicles with reasonable computational resources is noted and a survey of recent comparisons with experimental results is compiled. The importance of mixed attached and separated flow modeling for aeroelastic analysis is discussed, and recent calculations of periodic aerodynamic oscillations for an 18 percent thick circular arc airfoil are given. Author

N87-21875*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A COMPREHENSIVE ESTIMATE OF THE STATIC AERODYNAMIC FORCES AND MOMENTS OF THE 8 X 8 X 20 FT. CARGO CONTAINER
LUIGI CICOLANI and GERD KANNING May 1987 84 p
(NASA-TM-89433; A-87126; NAS 1.15:89433) Avail: NTIS HC A05/MF A01 CSCL 01A

A comprehensive static aerodynamic simulation model of the 8 by 8 by 20 ft MILVAN cargo container is determined by combining the wind tunnel data from a 1972 NASA Ames Research Center study taken over the restricted domain (0 is less than or equal to phi is less than or equal to 90 degrees; 0 is less than or equal to alpha is less than or equal to 45 degrees) with extrapolation relations derived from the geometric symmetry of rectangular boxes. It is found that the aerodynamics of any attitude can be defined

from the aerodynamics at an equivalent attitude in the restricted domain (0 is less than phi is less than 45 degrees; 0 is less than alpha is less than 90 degrees). However, a similar comprehensive equivalence with the domain spanned by the data is not available; in particular, about two-thirds of the domain with the absolute value of alpha is greater than 45 degrees is unrelated to the data. Nevertheless, as estimate can be defined for this region consistent with the measured or theoretical values along its boundaries and the theoretical equivalence of points within the region. These descrepancies are assumed to be due to measurement errors. Data from independent wind tunnel studies are reviewed; these are less comprehensive than the NASA Ames Research Center but show good to fair agreement with both the theory and the estimate given here. Author

N87-22623# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
INVESTIGATION OF PERIODIC PITCHING THROUGH THE STATIC STALL ANGLE OF ATTACK M.S. Thesis
ERIC C. STEPHEN Mar. 1987 150 p
(AD-A179512; AFIT/GAE/AA/87M-4) Avail: NTIS HC A07/MF A01 CSCL 20D

The flow over an NACA 0015 airfoil undergoing periodic pitching motions using constant pitch rate ramps was experimentally studied over a range of pitch rates and angles of attack. Surface pressure transducers coupled with a microcomputer-based data acquisition system were used to collect surface pressure data at a rate of 4000 samples per second. The data was reduced through numerical integration of the pressure data to provide graphs of the coefficients of lift, pressure drag and pitching moment versus time. Each point on the graphs represents an average of five runs. The results were compared according to their nondimensional pitch rates (defined as the product of one-half the chord length and the pitch rate divided by the freestream velocity). Data was collected in the range of nondimensional pitch up rates between 0.104 and 0.384 and the range of angles of attack between 0 and 30 degrees. GRA

N87-22624# Ballistic Research Labs., Aberdeen Proving Ground, Md.
NUMERICAL SIMULATION OF SUPERSONIC FLOW OVER A ROTATING BAND USING FLOWFIELD BLANKING
JUBARAJ SAHU Dec. 1986 34 p
(AD-A178492; BRL-MR-3561) Avail: NTIS HC A03/MF A01 CSCL 20D

Implicit, approximately factored, finite difference codes have been developed for solving the Navier-Stokes equations in general body-fitted coordinates. For a protuberance such as the rotating band on artillery shell, sharp geometric variations exist which make it extremely difficult to generate body conforming grids while preserving the sharp corners. Using wrap around grids for such cases introduces geometric errors and may lead to degradation of computational efficiency and accuracy. This report describes the development and application of a computational procedure using flowfield blanking to compute the flow over a rotating band at supersonic speed with no geometric error. GRA

N87-22627*# National Aeronautics and Space Administration, Washington, D.C.
THE AERODYNAMIC OPTIMIZATION OF WINGS AT SUBSONIC SPEEDS AND THE INFLUENCE OF WINGTIP DESIGN Thesis
H. ZIMMER May 1987 105 p Transl. into ENGLISH of "Die Aerodynamische Optimisrung von Tragfluegeln im Unterschallgeschwindigkeitsbereich und der Einfluss der Gestaltung der Fluegelenden" Stuttgart (West Germany), 1983 122 p Original language document was announced in IAA as A84-36992 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.
(Contract NASW-4006)
(NASA-TM-88534; NAS 1.15:88534) Avail: NTIS HC A06/MF A01 CSCL 01A

Some of the objectives of modern aircraft development are related to the achievement of reduced fuel consumption and aircraft noise. This investigation is mainly concerned with the aerodynamic aspects of aircraft development, i.e., reduction of induced drag. New studies of wing design, and in particular wing tips, are considered. Induced drag is important since, in cruising flight, it accounts for approximately one-third of the entire drag for the aircraft, and one-half while climbing. A survey is presented for the wing geometries and wing tip designs studied, and theoretical investigations of different planar wings with systematically varied wing tip forms are conducted. Attention is also paid to a theoretical study of some planar and nonplanar wings and their comparison with experimental data. Author

N87-22628# National Aeronautical Establishment, Ottawa (Ontario).
FLUTTER ANALYSIS OF A TWO-DIMENSIONAL AIRFOIL WITH CUBIC NON-LINEAR RESTORING FORCE
B. H. K. LEE and P. LEBLANC Feb. 1986 49 p
(NAE-AN-36; NRC-25438) Avail: NTIS HC A03/MF A01

Flutter analysis of a two dimensional airfoil with a cubic nonlinear restoring force in the pitch degree of freedom is investigated. The structural dynamic equations of motion are integrated by a time marching finite difference scheme. Flutter is determined from conditions which give rise to either a divergent or limit-amplitude solution. Case studies using various airfoil parameters and coefficients of the nonlinear term in the restoring force are carried out. The effect of initial conditions is studied by varying the displacement from equilibrium of the pitch angle at the start of the airfoil motion. For a soft spring, an increase in the initial angular displacement can induce flutter to occur below the linear flutter speed. Factors that have stabilizing and destabilizing effects are investigated. For a hard spring, divergent flutter is not encountered. Instead, the oscillations maintain a self-limited amplitude which is independent of initial angular displacement. The effects of airfoil parameters on the amplitudes of heave and pitch motions are studied. Author

N87-22629*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A LOOK AT HANDLING QUALITIES OF CANARD CONFIGURATIONS
SETH B. ANDERSON Sep. 1986 49 p Previously announced in IAA as A87-32226
(NASA-TM-88354; A-86332; NAS 1.15:88354) Avail: NTIS HC A03/MF A01 CSCL 01A

The first human-powered flight was achieved by a canard-configured aircraft (Wright Brothers). Although other canard concepts were flown with varying degrees of success over the years, the tail-aft configuration has dominated the aircraft market for both military and civil use. Reviewed are the development of several canard aircraft with emphasis on stability and control, handling qualities, and operating problems. The results show that early canard concepts suffered adversely in flight behavior because of a lack of understanding of the sensitivities of these concepts to basic stability and control principles. Modern canard designs have been made competitive with tail-aft configurations by using appropriate handling qualities design criteria. Author

N87-22631*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
RESULTS OF THE INTEGRATION OF A TRANSONIC FULL-POTENTIAL ANALYSIS PROGRAM WITH A FREE-WAKE LIFTING-LINE PROGRAM FOR HOVERING ROTORS
SONG-YOUNG CHUNG May 1987 22 p
(NASA-TM-89494; A-87193; NAS 1.15:89494) Avail: NTIS HC A02/MF A01 CSCL 01A

The hovering performance predictions of the TFAR1 and OPLIN codes and the experimental data are discussed. The TFAR1 program solves the full-potential equation in a rotor-fixed coordinate system by use of the line relaxation method. The OPLIN program calculates the positions of wake vortices and rotor performance using the influence-coefficient-and-lifing-line method. The two programs are combined by adding the induced velocities from the OPLIN code to the near flow-field of the rotor from the TFAR1 code. Results show that the TFAR1 program converges better

with the downwash-coupling method than the twist correction method to include the wake downwash. Author

N87-22633*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
VERIFICATION OF PERFORMANCE RESULTS FOR A LOW-SPEED 15 PERCENT ELLIPTICAL CIRCULATION CONTROL AIRFOIL
L. C. RODMAN and N. J. WOOD Feb. 1986 65 p
(Contract NAG2-173)
(NASA-CR-181020; NAS 1.26:181020; JIAA-TR-56) Avail: NTIS HC A04/MF A01 CSCL 01A

Low-speed wind tunnel tests performed by the Naval Ship Research and Development Center (NSRDC) on a circulation control airfoil model was repeated by the Joint Institute for Aerodynamics and Acoustics in an attempt to reproduce the performance results. The model used was a 15% ellipse with interchangeable trailing edges. Surface pressure measurements were taken to obtain lift and pitching moment coefficients as functions of jet blowing momentum, and the momentum deficit in the wake was measured and used to calculate the drag coefficient. The effects of spanwise slot height variation and of leading edge blowing on performance were also investigated. The performance results showed that of the three slot heights tested, a slot height/chord ratio of 0.0022 produced the most lift coefficient for a given blowing rate. Lift obtained in the current test ranged from 2 to 35% lower than the NSRDC test. However, the two data sets compared reasonably well considering wind tunnel and wall blowing scheme differences. The spanwise lift distribution showed less change in lift due to a variation in slot height than expected. The leading edge blowing results demonstrated that although lift initially decreased, a positive lift increment was possible at higher leading edge blowing rates. M.G.

03

AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A87-35424
LOSS OF CABIN PRESSURE IN CANADIAN FORCES TRANSPORT AIRCRAFT, 1963-1984
C. J. BROOKS (DND, Maritime Command, Halifax, Canada) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 58, March 1987, p. 268-275.

A review of all transport aircraft accidents and incidents in the Canadian Forces over the last 22 years (1963-1984) has been carried out. There have been 47 cases of serious loss of cabin pressurization. Altitudes varied from 2133 to 11277 m. The CC 130 Hercules appears to be the most vulnerable (62 percent). The most common cause was mechanical in origin (70 percent). There were two definite cases of hypoxia, and oxygen masks were deliberately deployed in nine cases. No deaths or permanent injuries occurred. Loss of pressurization is an extremely low, but definite risk to the pilot and passengers. Thus, aeromedical training with practical demonstrations in the hypobaric chamber for aircrew and flight attendants should continue. Author

A87-35560
FIGHT AGAINST BIRD STRIKES CONTINUES
J. L. BRIOT (Service Technique de la Navigation Aerienne, Paris, France) ICAO Bulletin, vol. 42, Jan. 1987, p. 17, 18.

French experiments, from 1983-1986, in clearing runways of birds to avoid their collisions with aircraft are summarized. The experiments were carried out at two airports with a large variety of bird species and over 400 aircraft arrivals/departures per day. The methods examined included: falcons, loudspeaker broadcasts of bird distress calls, firing of pyrotechnic rockets and firing lead shot at various species. Continuous release, retrieval and re-release of radio-banded falcons lowered the collision rates by 60 pct for species hunted by falcons and 30 pct overall. A combination of the other three techniques lowered collision rates by 75 pct. The use of falcons was no more effective than other methods, while a combination of the other three, by dedicated personnel, can be highly cost-effective, provided human inhabitants in nearby dwellings can tolerate the extensive use of noise-generating equipment. M.S.K.

A87-35919
THE PROBLEM OF THE MAXIMUM FLIGHT RANGE OF AIRCRAFT [O ZADACHE POLETA LETATEL'NOGO APPARATA NA MAKSIMAL'NUIU DAL'NOST']
O. G. PRIVALOVA Moskovskii Universitet, Vestnik, Seriia 1 - Matematika, Mekhanika (ISSN 0579-9368), no. 1, Jan.-Feb. 1987, p. 78-81. In Russian. refs

The problem of the maximum flight range is analyzed for the case of long flight times. The initial variational problem is reduced to that of solving a system of nonlinear differential equations with certain boundary conditions. The system is solved by applying, consecutively, Bellman's (1968) quasi-linearization procedure and Godunov's (1961) finite difference scheme. The characteristic features of the optimal trajectories are examined. V.L.

A87-36284
WEIGHT GROWTH IN AIRLINE SERVICE
J. H. WOOD (British Airways, PLC, Hounslow, England) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 15 p.
(SAWE PAPER 1698)

It is noted that while many people in the airline service industry associate weight growth only in connection with an aircraft there are other factors which must be considered as well. Passenger weights, baggage weights, removable catering, and crew weights all affect the revenue payload that can be carried. Areas where weight growth has occurred and the reasons for it are examined. Graphs are presented showing the actual weight growth for various aircraft types including the B747, Tristar, B757, B737, 1-11, and Concorde. D.H.

A87-36768
FLIGHT TESTS AIMED AT MEASURING POWER REDUCTION IN FORMATION FLIGHT [FLUGVERSUCHE ZUR MESSUNG DER LEISTUNGERSPARNIS IM VERBANDSFLUG]
M. BEUKENBERG and D. HUMMEL (Braunschweig, Technische Universitaet, Brunswick, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 138-145. In German. DFG-supported research. refs
(DGLR PAPER 86-128)

The power reduction occurring during formation flight of two identical aircraft was measured using lifting surface theory. The theoretical results showed that the use of just two aircraft saved 15 percent of the combined power requirements for both aircraft traveling alone. The total savings and their distribution over the two aircraft depended on the aircraft geometric parameters and on the flight formation of the aircraft. Actual flight tests resulted in power reductions which were of the same order of magnitude as those predicted by the theory. The dependence of the reduction on the relative positions of the two aircraft was also in agreement with theory. C.D.

A87-37770#
MULTI-AXIS SEAT EJECTION (MASE) SLED
LARRY C. MIXON and JAMES D. CUMMINGS (USAF, Test Track Div., Holloman AFB, NM) SAFE Journal, vol. 17, Spring 1987, p. 16-22. refs

The design, development, and capabilities of the MASE sled used for escape system testing are described. The main elements of the MASE sled are: a fiberglass fuselage mock-up; a fuselage positioning system and support base; a roll motion generation system; an upper frame system; and a sled undercarriage. The

MASE sled will allow testing of fighter size mock fuselages at velocities up to 725 knots equivalent air speed, angles of attack varied to +/- 30 deg in pitch and +/- 20 deg in yaw, and static and dynamic roll capabilities. Diagrams of the components of the MASE sled are presented. I.F.

A87-38478#
BOEING 747 CRASH ACCIDENT - A THEORETICAL CONSIDERATION ON THE FRACTURES OF THE STRUCTURE. II - ON DFDR RECORDS
HIROICHI OHIRA Kyushu University, Technology Reports (ISSN 0023-2718), vol. 59, Oct. 1986, p. 725-732. In Japanese, with abstract in English. refs

The paper concerns with the crash accident of Boing 747 occurred in Japan in August, 1985. The records of the flight recorder published by the authority are examined. Methods of reading time on different pages of the records are given. Magnified pictures of the phenomena are presented for a time interval of five seconds which is most related to the structural fracture. A temporary attempt is made to read the implications of the phenomena. Author

A87-38693#
SYMPOSIUM ON VEHICLE CRASHWORTHINESS INCLUDING IMPACT BIOMECHANICS; PROCEEDINGS OF THE WINTER ANNUAL MEETING, ANAHEIM, CA, DEC. 7-12, 1986
PIN TONG, ED. (DOT, Washington, DC), CHI-MOU NI, ED. (GM Research Laboratories, Warren MI), A. KING, ED., and S. LANTZ, ED. (Wayne State University, Detroit, MI) Symposium sponsored by ASME. New York, American Society of Mechanical Engineers, 1986, 162 p. For individual items see A87-38694 to A87-38697.

The present conference on vehicular crashworthiness considers the experimental results of a controlled impact demonstration philosophy, the reconstruction of Space Shuttle crashworthiness on the basis of the Challenger accident, simulations of passenger responses to transport aircraft accidents, helicopter structural crashworthiness, and the impact tolerance and response of the human face. Also discussed are biomedical response and injury tolerance of lower abdominal impact, the assessment of the state of vehicle crashworthiness on the basis of test data, a method of vehicle structural response characterization in barrier collisions, constrained system identification of nonlinear structures in the adaptive time domain, CAD analysis methods for vehicle structural crashworthiness, and a three-dimensional computer crashworthiness analysis program for thin wall beam component vehicle structures. O.C.

A87-38694#
THE CONTROLLED IMPACT DEMONSTRATION (CID STRUCTURAL EXPERIMENTS, PHILOSOPHY, AND RESULTS)
C. A. CAIAFA and L. M. NERI (FAA, Technical Center, Atlantic City, NJ) IN: Symposium on Vehicle Crashworthiness Including Impact Biomechanics; Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 1-29. refs

An analysis of transport aircraft accident history has indicated that the record for occupant safety in survivable accidents is excellent. The correlation between analytical modeling of full scale airframe sections and a complete-aircraft impact test is also excellent, encouraging the use of analytical modeling for crashworthiness. The data from controlled impact demonstration methodology testing presently discussed for seat/restraint experiments indicate that air-to-ground impact did not produce sufficient deceleration levels to substantially deform or fracture any of the seat/restraint units used, precluding their crashworthiness evaluation. O.C.

N87-21876# Naval Postgraduate School, Monterey, Calif.
A DECISION SUPPORT SYSTEM FOR THE DIAGNOSIS OF AIRCRAFT EMERGENCIES
OLEN D. PORTER Dec. 1986 89 p
(Contract MIPR-ATEC-88-86)
(AD-A177394; NPS52-86-027) Avail: NTIS HC A05/MF A01 CSCL 05I

The purpose of this research is to show the feasibility of an expert system utilizing the existing sensors aboard an aircraft to aid the pilot in the diagnosis of single and compound emergencies. A passive expert planner is proposed that utilizes multiple and domain dependent knowledge bases. The system is implemented on a personal computer, using the USMC AH-1T attack helicopter as a modeling platform. An effort is made to quantify the amount of information processing necessary to adequately define emergencies. Performance of the system was also evaluated. GRA

N87-21877 Tennessee Univ., Knoxville.
AN EXPERIMENTAL AND THEORETICAL INVESTIGATION OF AN AIR INJECTION TYPE ANTI-ICING SYSTEM FOR AIRCRAFT Ph.D. Thesis
ABDOLLAH HADDAD TABRIZI 1986 299 p
Avail: Univ. Microfilms Order No. DA8701826

An anti-icing system was investigated in connection with the ice accretion on an aircraft engine inlet and wing leading edge. Air injection at the leading edge was used to prevent supercooled water droplets in the atmosphere from striking the surface. Through the consideration of the droplet dynamics in a two-phase flow, i.e., air-water droplets, the effectiveness and feasibility of air injection as a means of anti-icing technique was studied. An experimental investigation was also undertaken to complement the analytical study. An experimental model of a circular cylinder with injection slots was tested in a two-phase flow environment in a wind tunnel. A circular cylinder was used as an approximation of the leading edge of an engine inlet and a wing. It was shown that air injection at the leading edge-reduces the ice collection rate and that the ice reduction rate is dependent on the air injection rate and location of the injection as well as the number of slots. The ice reduction due to the surface injection was determined by weighing the ice collected on the model. Dissert. Abstr.

N87-21878*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AIRCRAFT ACCIDENT REPORT: NASA 712, CONVAIR 990, N712NA, MARCH AIR FORCE BASE, CALIFORNIA, JULY 17, 1985, EXECUTIVE SUMMARY
BYRON E. BATTHAUER, G. T. MCCARTHY, MICHAEL HANNAH, ROBERT J. HOGAN, FRANK J. MARLOW, WILLIAM D. REYNARD, JANIS H. STOKLOSA, and THOMAS J. YAGER (National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.) Jul. 1986 9 p
(NASA-TM-87356-VOL-1; E-3110; NAS 1.15:87356-VOL-1) Avail: NTIS HC A02/MF A01 CSCL 01C

On July 17, 1985, NASA 712, a Convair 990 aircraft, was destroyed by fire during an aborted takeoff at March Air Force Base in California. Material ejected from a blowout in the tires of the right main landing gear penetrated the right-wing fuel tank. The leaking fuel ignited. Fire engulfed the right wing and fuselage as the aircraft stopped its forward motion. The crew of four and the 15 scientists and technicians aboard escaped without serious injury. Author

N87-21879*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AIRCRAFT ACCIDENT REPORT: NASA 712, CONVAIR 990, N712NA, MARCH AIR FORCE BASE, CALIFORNIA, JULY 17, 1985, FACTS AND ANALYSIS
BYRON E. BATTHAUER, G. T. MCCARTHY, MICHAEL HANNAH, ROBERT J. HOGAN, FRANK J. MARLOW, WILLIAM D. REYNARD, JANIS H. STOKLOSA, and THOMAS J. YAGER (National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.) Jul. 1986 59 p
(NASA-TM-87356-VOL-2; E-3110; NAS 1.15:87356-VOL-2) Avail: NTIS HC A04/MF A01 CSCL 01C

On July 17, 1985, at 1810 P.d.t., NASA 712, a Convair 990 aircraft, was destroyed by fire at March Air Force Base, California. The fire started during the rollout after the pilot rejected the takeoff on runway 32. The rejected takeoff was initiated during the takeoff roll because of blown tires on the right landing gear. During the rollout, fragments of either the blown tires or the wheel/brake assemblies penetrated a right-wing fuel tank forward of the right main landing gear. Leaking fuel ignited while the aircraft was rolling, and fire engulfed the right wing and the fuselage after the aircraft was stopped on the runway. The 4-man flightcrew and the 15 scientists and technicians seated in the cabin evacuated the aircraft without serious injury. The fire was not extinguished by crash/rescue efforts and the aircraft was destroyed. Author

N87-22342*# National Transportation Safety Board, Washington, D. C.
COMMENTS ON THE PROBLEM OF TURBULENCE IN AVIATION
JAMES C. MCLEAN, JR. *In* NASA. Langley Research Center Atmospheric Turbulence Relative to Aviation, Missile and Space Programs p 11-16 Apr. 1987
Avail: NTIS HC A12/MF A01 CSCL 01C

The problem of turbulence since the beginning of aviation is traced. The problem was not cured by high altitude flight and was acerbated by the downbursts associated with thunderstorms. The accidents that occurred during the period 1982 to 1984 are listed. From this is extracted the weather related accidents. Turbulence accounts for 24% of the accidents involving large commercial carriers and 54% of the weather related accidents. In spite of all the efforts to improve the forecasting and detection of turbulence, the problem is still a large one. E.R.

N87-22343*# Air Force Inspection and Safety Center, Norton AFB, Calif.
DOD (USAF) TURBULENCE ACCIDENTS AND INCIDENTS
DOUGLAS MILLER *In* NASA. Langley Research Center Atmospheric Turbulence Relative to Aviation, Missile and Space Programs p 17-25 Apr. 1987
Avail: NTIS HC A12/MF A01 CSCL 01C

A summary of Air Force turbulence related mishaps for the last ten years of Air Force mishaps is presented from a perspective of where it has been, where it is now, and where it is going. In addition to accounts of major mishaps, a summary of what actions were taken to preclude future similar mishaps is presented. Also, a discussion of some of the things being done now and being planned for the future to prevent turbulence related mishaps is presented. Author

N87-22605*# Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 1984
ROBERT W. SIMPSON *In* NASA. Langley Research Center Joint University Program for Air Transportation Research, 1984 p 3-7 May 1987
Avail: NTIS HC A08/MF A01 CSCL 01C

Three projects sponsored by the Joint University Program at MIT are summarized. Two projects were focussed on the potential application of Loran-C in flying nonprecision approaches to general aviation runways, and the third project involved research on aircraft icing. In one Loran-C project, Aircraft Approach Guidance Using Relative Loran-C Navigation, the concept was flight tested. It used the difference in TD's from those of the touchdown point to simplify and speed navigation computer processing and took advantage of the short term accuracy of less than 100 feet for Loran-C. The goal of the project, Probabilistic Modelling of Loran-C Error for Nonprecision Approaches, was to develop a mathematical model which would predict the probability that an approach flown to a runway with a particular Loran-C receiver would fall within a given standard. The Aircraft Icing project focussed on measurement of droplet trajectories and droplet impingement/runback characteristics and measurement of real time ice accretion using ultrasonic pulse echo techniques. E.R.

N87-22609*# Ohio Univ., Athens.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT OHIO UNIVERSITY, 1984
RICHARD H. MCFARLAND *In* NASA. Langley Research Center Joint University Program for Air Transportation Research, 1984 p 45-48 May 1987
Avail: NTIS HC A08/MF A01 CSCL 01C

The operational development of Loran-C for enroute navigation and nonprecision approaches was studied, and is only one of the many projects funded by the Joint University Program for Air Transportation at Ohio University. Other projects included work on the DATAC data bus monitor, global positioning system test bed receiver development, fiber optic data bus application in general aviation aircraft, and advanced remote monitoring techniques. E.R.

N87-22619*# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
INVESTIGATION OF AIR TRANSPORTATION TECHNOLOGY AT PRINCETON UNIVERSITY, 1984
ROBERT F. STENGEL *In* NASA. Langley Research Center Joint University Program for Air Transportation Research, 1984 p 133-137 May 1987
Avail: NTIS HC A08/MF A01 CSCL 01C

The Air Transportation Technology Program at Princeton University, a program emphasizing graduate and undergraduate student research, proceeded along four avenues during 1984: (1) guidance and control strategies for penetration of microbursts and wind shear; (2) application of artificial intelligence in flight control systems; (3) effects of control saturation on closed loop stability; and (4) response of open loop unstable aircraft. Areas of investigation relate to guidance and control of commercial transports as well as to general aviation aircraft. Interaction between the flight crew and automatic systems is a subject of principle concern. These areas of investigation are briefly discussed. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A87-35337
A NONLINEAR TRACKER USING ATTITUDE MEASUREMENTS
DOMINICK ANDRISANI (Purdue University, West Lafayette, IN), FRANK P. KUHL (U.S. Army, Armament Research Development and Engineering Center, Dover, NJ), and DANIEL GLEASON (USAF, Institute of Technology, Wright-Patterson AFB, OH) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-22, Sept. 1986, p. 533-539. refs

The subject of this paper involves tracking the present position of a maneuvering aircraft as well as predicting its future position. A tracking filter is developed that uses aircraft attitude angles (yaw, pitch, roll) in addition to the usual radar measurements. Computer simulation of tracker performance when tracking violently

maneuvering aircraft indicates that a dramatic improvement is obtained by using attitude information. The approach taken is to develop a 12or 15-state extended Kalman filter that models both translational and rotational degrees of freedom. By measuring and estimating attitude it is possible to approximately determine the magnitude and direction of the force system acting on the vehicle and therefore determine vehicle linear acceleration. Knowledge of acceleration is then used to improve the estimate of present and future position of the vehicle being tracked. Simulation of a T-38 aircraft performing a 5 g turn indicates that the new tracker produces maximum trajectory prediction errors that are 36 percent of the errors experienced by more conventional trackers. Author

A87-35340
EXPERIMENTAL DETECTION OF ANOMALOUS MODE-C REPORTS USING RADAR DATA
MICHAEL P. MCLAUGHLIN (Mitre Corp., Metrek Div., McLean, VA) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-22, Sept. 1986, p. 559-564. refs

A new methodology to scan automated radar terminal system (ARTS-III) data for aircraft tracks exhibiting probable mode-C encoder/transponder faults is described. The tracks of more than 8000 climbing or descending aircraft, recorded at the Seattle-Tacoma terminal area, were analyzed using this method. Based on this sample, the probability of the previously recognized 'stuck C-bit' error is estimated to be 0.44 percent (0.31-0.61 percent, 95 percent confidence). In addition, a new, more subtle error, here termed the 'deficient response', was discovered which is estimated to occur with a probability of 0.77 percent (0.59-0.98 percent, 95 percent confidence). Subsequent tests found this new error to have much less impact on traffic alert and collision avoidance system (TCAS) performance than does the stuck C-bit error. Author

A87-35342
ON-LINE VEHICLE MOTION ESTIMATION FROM VISUAL TERRAIN INFORMATION. I - RECURSIVE IMAGE REGISTRATION. II - GROUND VELOCITY AND POSITION ESTIMATION
SHMUEL J. MERHAV and YORAM BRESLER (Technion - Israel Institute of Technology, Haifa) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-22, Sept. 1986, p. 583-604. Research supported by the Ministry of Defense. refs (Contract MODI-95234837101)

The first part of the present treatment of the estimation of motion on the basis of the optical flow observed by a down-looking airborne electrooptical sensor gives attention to a velocity/height ratio estimation algorithm which implements the recursive registration of successive images by using the gradient of a similarity function between them to control the tracking of their relative drift. Substantial memory and computation savings over full frame registration are obtained through the use of only a single line in the TV frame. The second part of this work demonstrates how the information furnished by the motion estimator can be integrated with additional on-board sensors to yield a complete and autonomous navigation system. O.C.

A87-35557
AVAILABILITY AND MAINTAINABILITY OF THE RAMP MONOPULSE SSR SYSTEMS
PAUL MCCARTHY (Cossor Electronics, Ltd., Harlow, England) ICAO Bulletin, vol. 42, Jan. 1987, p. 9-11.

The maintainability and availability requirements for the secondary surveillance radar (SSR) for ATC functins in the Canadian Radar Modernization Project (RAMP) are summarized. The high availability required will necessitate the provision of accurate fault data to maintenance centers. Built-in test equipment (BITE) will be responsible for isolating faults in line-replaceable modules. Arrangements of the data paths to be followed by the BITE interrogations and identifications are discussed. Conditions under which switchovers will be effected are considered, along with the probabilities of faults, fault detection and failure of finding a fault. Techniques being applied to lower the risk of ambiguity in the fault-detection equipment and procedures are described. M.S.K.

A87-35558
NEW CONCEPTS CONCERNING ILS SITING
R. H. MCFARLAND (Ohio University, Athens) ICAO Bulletin, vol. 42, Jan. 1987, p. 12-14.

Engineering capabilities which now permit the installation of ILS systems at any airport where physical obstruction criteria can be met are delineated. The new capabilities are based on sophisticated numerical models for ILS performance for a given topography, the use of vector voltmeters for measuring and setting antenna drive currents with precision, the availability of non-image glide path systems, the use of directional antennas and arrays, and the independence of glide-path placement from the reference system center. Methods for satisfying siting criteria in the placement of a 21.1 m height side-band reference antennas and localizers are discussed. Recently-developed technologies which permit combining course and clearance arrays into a single array are noted. M.S.K.

A87-35559
LOW COST AIR SURVEILLANCE RADAR DEVELOPED
NORMAN WILKINS (Racal Avionics, Ltd., Ground Systems Div., New Malden, England) ICAO Bulletin, vol. 42, Jan. 1987, p. 15, 16.

Features of a new 30 kW, S-band, low-cost surveillance radar system with a color display are described. The system is intended for local area surveillance, surveillance radar approaches, ATC, radar monitoring of ILS/MLS approaches and vectoring/sequencing for ILS/MLS or radar approaches. The system consists of the radar head, with antenna, turning gear and transceiver, and the display, which includes the viewing unit, scan conversion circuits, and 625 raster display and radar controls. Color coding schemes for the flicker-free displays are described, noting the absence of image fading between scans. The 12-ft wide antenna emits a beam centered 15 deg above the horizontal while allowing surveillance of surface traffic. The low mass and easy installation of the system commends its use as a mobile/transportable system. M.S.K.

A87-36588
FLIGHT TESTING OF FLIGHT CONTROL AND NAVIGATION EQUIPMENT [LETNYE ISPYTANIIA SISTEM PILOTAZHNO-NAVIGATSIONNOGO OBORUDOVANIIA]
EVGENII GRIGOREVICH KHARIN, ED. Moscow, Izdatel'stvo Mashinostroenie, 1986, 136 p. In Russian. No individual items are abstracted in this volume.

The book contains methods and procedures for the flight testing of the principal flight control and navigation systems. The discussion covers an evaluation of the accuracy of automatic flight control systems from test data; flight testing and evaluation of gyroscopic and astronavigation systems; and determination of corrections for pitot-static tubes. Attention is also given to the testing of danger-warning systems and radio navigation and landing systems. V.L.

A87-36769
INTEGRATED INERTIAL REFERENCE DEVICE FOR FLIGHT CONTROL AND NAVIGATION [INTEGRIERTE INERTIAL-REFERENZANLAGE FUER FLUGREGELUNG UND NAVIGATION]
UWE KROGMANN (Bodenseewerk Geraetetechnik GmbH, Ueberlingen, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 146-158. In German. refs
(DGLR PAPER 86-150)

An inertial reference device is described which provides a highly reliable, failure-tolerant sensor for realizing a failsafe flight control system for CCV-type aircraft. The device employs a strapdown inertial system whose structure, sensors, and data processing are described in detail. The use of several such devices as multifunction

reference instruments is considered, including the navigational aspects, redundancy control, failure recognition, and reliability. Such instruments can fulfill both the accuracy requirements of navigation and the extreme reliability requirements of flight control. C.D.

A87-36780
LOW ALTITUDE AIRCRAFT TRACKING AND REGISTRATION SYSTEM
N. M. VEPA and K. REIMANN (Contraves GmbH, Stockach, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 239-245 .
(DGLR PAPER 86-137)

The functions and performance features of the Skyguard low level aircraft tracking and registration system are described. The physical factors of resolution, contrast, and illumination under which this system works are briefly reviewed, and the relevant system parameters are given. Other promising applications for this system besides aircraft tracking and registration are discussed, including air space surveillance and monitoring, air crew ECM training, radar cross section measurement, weapon delivery training, drone monitoring, cine theodolite allocation, and training systems for air defense control. C.D.

A87-36784
SYNTAX ANALYSIS FOR A COCKPIT SPEECH RECOGNITION SYSTEM [SYNTAXANALYSE FUER EIN SPRACHERKENNUNGSSYSTEM IM COCKPIT]
K. TAUBENBERGER (Elektronik-System-Gesellschaft mbH, Munich, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 276-280. In German. refs
(DGLR PAPER 86-158)

A speech-recognition system for use in aircraft cockpits consisting of an individual word recognition system for syntactic and pragmatic evaluation is described. The word evaluation is sequential, corresponding to the mission phase, and hierarchic, corresponding to the avionic component system. This syntactic tree structure is similar both to paging procedures and to the indicators in head-down displays and central display units. This minimizes the number of necessary reference patterns for a given vocabulary, and assures a high probability of recognition. C.D.

A87-37401#
FLIGHT TEST AIRBORNE DATA PROCESSING SYSTEM
LEE H. ECCLES and JOHN J. MUCKERHEIDE (Boeing Commercial Airplane Co., Seattle, WA) IN: ITC/USA/'86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 367-375.

The subsystems of one particular flight test airborne data processing system are described. The system is built around two buses, one for passing setup and control information between system elements and the other for passing periodic data between the units. The data originate in sensors installed by the flight test or in black boxes on the aircraft. These buses interconnect a number of different processors. The application processor runs the application programs and drives the display devices. The file processor handles the mass storage devices and common peripheral devices. The acquisition interface assembly is the entry point for data. It accepts serial PCM data from either the data acquisition system or the tape recorder. These data are then concatenated, converted to engineering units, and passed to the rest of the system for further processing and display. C.D.

A87-37402#
HELICOPTER FLIGHT TESTING AND REAL TIME ANALYSIS WITH DATA FLOW ARRAY PROCESSORS
EDWARD L. DAVIS and WILLIAM E. GRAHAME (Loral Instrumentation, San Diego, CA) IN: ITC/USA/'86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 377-381.

A complete acquisition and analysis system is presented that contains modularly expandable array processors which provide real time acquisition, processing, and analysis of multiple concurrent data streams and parameters. The system checks simple limits and converts engineering units, as well as performs more complex spectrum analyses, correlations, and other high-level processes interactively with the operator. A sample configuration is presented which illustrates how the system interacts with the operator during an actual flight test. The derived parameters are discussed, and the roles they play in decision-making are demonstrated. C.D.

A87-37406#
FLIGHT INSTRUMENTATION TELEMETRY FOR AEROSPACE APPLICATION
P. S. RAJYALAKSHMI and R. K. RAJANGAM (Indian Space Research Organization, Digital Systems Div., Bangalore, India) IN: ITC/USA/'86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 409-419.

An L-band PCM/FM telemetry system containing a Stored Program Multiplexer, 12-bit ADC, and other digital interfaces for performing measurements has been developed as a flight instrumentation telemetry facility. The design philosophy is summarized, and the design details pertaining to the signal conditioners, encoder, and L-band transmitter are described. The features and the results of tests done on the system are reviewed, including those from the temperature and altitude test, vibration test, shock test, humidity test, salt fog test, and EMI/EMC test. Finally, the flight test performance of the system is described. C.D.

A87-37414#
AIRBORNE TELEMETRY AND THE ADVANCED MEDIUM RANGE AIR-TO-AIR MISSILE
MARK S. PLECITY (USAF, Advanced Range Instrumentation Aircraft Programs Div., Wright-Patterson AFB, OH) IN: ITC/USA/'86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 501-504.

The Advanced Range Instrumentation Aircraft (ARIA) is an airborne platform to receive, record, process and retransmit telemetry data. This paper presents a summaary of ARIA's capabilities with emphasis on airborne testing of the Advanced Medium Range Air to Air Missile (AMRAAM) program. The unique test scenarios, as well as current and future telemetry requirements of the AMRAAM test program are discussed. Author

A87-37415#
AN AIRBORNE TELEMETRY RELAY SYSTEM FOR THE GULF RANGE
SEVERYN ZOLEDZIOWSKI (LTV Aerospace and Defense Co., Sierra Research Div., Buffalo, NY) IN: ITC/USA/'86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 505-517.
(Contract F08635-84-C-0253)

The Airborne Platform Telemetry Relay System (AP/TM) designed for the Gulf Range Instrumentation System is described together with its four subsystems (the telemetry data relay, the sea surveillance radar and radar data link, the drone control relay, and the UHF radio relay). The AP/TM will allow air-to-air missile test and training missions to be conducted beyond the line-of-sight of the land-based instruments. The telemetry data relay subsystem will receive telemetry signals from five independent sources and retransmit them to land-based receiving sites. The AP/TM will

also have the capability of relaying four channels of voice communications and drone tracking data and to perform sea surveillance of the mission area. Instrumentation diagrams and block diagrams are included. I.S.

A87-37416#
UC-880 TELEMETRY RELAY AIRBORNE COMMAND SYSTEM
WILLIAM D. ANDERSON (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: ITC/USA/'86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 521-530.

The Naval Air Test Center, Range Directorate, has developed a Telemetry Relay Airborne Command System (TRACS) utilizing a Convair UC-880 aircraft. In its present configuration, the UC-880 can receive, record, and display telemetry data in real time, reshape and retransmit the telemetry data, act as a command center for TOMAHAWK cruise missile operations, provide radar range surveillance, remotely control instruments, cameras, emitters, and electronic countermeasures equipment on target hulks, provide inflight refueling of aircraft, process and display on CRT's the maps of the area of operations and the missile profiles and tracks on the maps, and provide over-the-horizon target displays using a satellite communication system. This paper will present the development of the UC-880 TRACTS and the results of operations that utilized this system. The system characteristics, design constraints, and future plans will be discussed. Author

A87-37417#
INTEGRATED 1553 DATA BUS MONITOR SYSTEM
WILLIAM P. RUSSELL (U.S. Navy, Naval Air Test Center, Patuxent River, MD) IN: ITC/USA/ '86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 531-540.

An integrated 1553 Data Bus Monitor (DBM) System has been developed at the Naval Air Test Center. The system is capable of monitoring six 1553A or B channels and provides, in separate PCM streams, selected parameter data and all message traffic on the data bus (thruput). Thruput data can be split to two tape tracks per channel for bandwidth conservation. Selected parameter formats can be entered at the flight line with a hand-held programmer which communicates to the DBM via an RS-232 interface. PCM outputs are available for telemetry as well as for on-board recording. Analog and discrete data is incorporated in the system with A/D inputs, parallel inputs, or serial entry of PCM data from a remote PCM system. A 1553 remote terminal provides data to the F-18 mission conmputer. Existing systems are being used on AMRAAM Development in the F-18 and in follow-on F-18 development at the Naval Air Test Center. Author

A87-37418#
THE PACIFIC MISSILE TEST CENTER'S AIRBORNE TELEMETRY COLLECTION CAPABILITY
JIM ENGEL (U.S. Navy, Pacific Missile Test Center, Point Mugu, CA) IN: ITC/USA/'86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 541-547.

The salient features of the Pacific Missile Test Center in California are described together with the types and characteristics of the telemetry equipment (including antennas, pods, receivers, tape recorders, decommutation and display equipment, and retransmission capability) installed on several aircraft. Consideration is given to typical test scenarios; a typical long range missile ground track is included. Operational problems and planned improvements are also discussed. I.S.

A87-37426#
DATA ACQUISITION SYSTEM FOR AIRCRAFT QUALIFICATION
LEE ECCLES (Boeing Commercial Airplane Co., Seattle, WA), MICHAEL O'BRIEN, and WILLIAM ANDERSON (Fairchild Weston Systems, Inc., Sarasota, FL) IN: ITC/USA/'86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 651-660. Research supported by the Boeing Commercial Airplane Co.

The Acquisition Interface Assembly (AIA), which is an integral part of the Airborne Data Analysis and Monitor System (ADAMS) used for real time acquisition and analysis of flight test data, is described. The major functions of the AIA include simultaneous acquisition of data from three PCM streams; editing and processing the data and converting the processed data to a common engineering unit format; reporting data processing errors; processing the time information and merging it into the data stream; and controlling the flow of data and time to/from analog tape records and checking the recorded data for errors. The setup is programmable from a local terminal and other ADAMS processors. Each of the major AIA operations is discussed along with the respective equipment. Flow diagrams are included. I.S.

A87-37577#
AIRBORNE PULSE-DOPPLER RADAR - FALSE-ALARM CONTROL
P. WEBER, S. HAYKIN (McMaster University, Hamilton, Canada), and R. GRAY (CDC, Communications Research Centre, Ottawa, Canada) IEE Proceedings, Part F - Communications, Radar and Signal Processing (ISSN 0143-7070), vol. 134, pt. F, no. 2, April 1987, p. 127-134. refs

Constant false-alarm rate (CFAR) techniques are compared in an airborne pulse-Doppler detection application. Standard methods such as CA-CFAR, GO-CFAR and OS-CFAR prove to be inadequate in dealing with the extreme variations of power between radar cells, resulting in large CFAR losses. Two new techniques, nadir-blanked CFAR and gradient CFAR, were specifically designed to accommodate these variations. Nadir-blanked CFAR simply does not attempt detection in the first few gates that include or exceed the altitude range. Gradient CFAR does not perform as well as nadir blanking, but is still considerably better than standard CFAR methods. The method is similar to GO-CFAR, but the GO-threshold is boosted by the gradient between two groups of reference cells. Both methods allow for large reductions in the CFAR multiplying constant and therefore substantial improvements in detectability over the standard methods. Author

A87-38874#
FLIGHT INSPECTION PROCEDURES AND POSITION FIXING TECHNIQUES
D. R. REIFFER (Civil Aviation Authority, London, England) Journal of Navigation (ISSN 0020-3009), vol. 40, Jan. 1987, p. 120-131.

Flight inspection procedures in the U.K. are discussed. Flight inspection is the means by which the performance of a navigation aid is measured to ensure that it is meeting the requirements of the operational procedures upon which it is based. Techniques for fixing the position of aircraft for approaching and landing to + or - 0.001 deg and to + or - 0.1 nm for enroute operations are described. The techniques include: (1) air-to-ground photography, (2) theodolites, (3) a radio telemetry theodolite, (4) telecroscope, and (5) the Decca navigation system. Flight inspection procedures check on the effects of local environmental changes on initial performance and carry out quality control procedures on the general system. Methods for evaluating the position-fixing mechanism of aircraft and for establishing the operation conditions are examined. The applications of a microwave landing system and/or electronic theodolites for flight inspection are proposed. I.F.

A87-38875#
MILITARY FLIGHT CHECKING OF NAVIGATION AND LANDING AIDS
M. A. RADFORTH (RAF, London, England) Journal of Navigation (ISSN 0020-3009), vol. 40, Jan. 1987, p. 132-137.

The objectives of the RAF flight checking organization are examined. The limitations of the optical measuring systems are discussed. The basic components and navigation techniques associated with the new inertially reference flight inspection system (IRFIS) are described. IRFIS uses an inertial navigation system as the prime sensor with an automatic multi-distance measuring equipment update facility for navaid inspection, and a unique aircraft position sensor for accurate calibration of precision aids; a minicomputer performs all of the data processing and system management functions, and the operator controls the system through a keyboard and a video display unit. A typical calibration profile for a routine check of an instrument landing system is presented. I.F.

N87-21881# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Guidance and Control Panel.
EFFICIENT CONDUCT OF INDIVIDUAL FLIGHTS AND AIR TRAFFIC OR OPTIMUM UTILIZATION OF MODERN TECHNOLOGY FOR THE OVERALL BENEFIT OF CIVIL AND MILITARY AIRSPACE USERS
ANDRE BENOIT, ed. Loughton, England Dec. 1986 326 p In ENGLISH and FRENCH Symposium held in Brussels, Belgium, 10-13 Jun. 1986
(AGARD-CP-410; ISBN-92-835-0403-8) Avail: NTIS HC A15/MF A01

A number of issues related to air traffic control are investigated, with particular attention being paid to new technologies. Attention is focused on the use of more powerful data processing technologies, the introduction of satellites for integrated navigation communications and surveillance and the potential role of automatic two-way air/ground data links. The fields covered include advanced surveillance radar, advanced landing systems, the management of air traffic, the potential and limitations of automation, including the possible applications of intelligent knowledge based systems and new onboard equipment that wil necessitate a fresh look at the relationship between air traffic control and individual aircraft.

N87-21883# Eurocontrol Agency, Brussels (Belgium).
AIR NAVIGATION SERVICES AND AIRCRAFT AROUND THE YEAR 2000
V. VACHIERY *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 16 p Dec. 1986
Avail: NTIS HC A15/MF A01

The Air Traffic Services (ATS) System for 2000 and beyond shall have to cope with the constantly increasing traffic demand. It shall take wholly into account the methods by which the aircraft are conducted, and, in particular the ability to adhere accurately to a predefined profile. Since 1980 a working party of the EUROCONTROL Agency has been in charge of the development of a future system concept and the formulation of a corresponding research program. The objectives, the difficulties, the main principles and the characteristics associated with the development and implementation of the future ATS concept are reviewed. The necessity for close consultation between aircraft manufacturers, avionics manufacturers, aircraft operators and the authorities responsible for air traffic management is discussed. Author

N87-21885# Societe d'Applications Generales d'Electricite et de Mecanique, Paris (France). Dept. Aeronautique.
INERTIAL-GPS: A MARRIAGE OF REASON, AN ANALYSIS [INERTIE-GPS: UN MARIAGE DE RAISON - A L'ESSAI]
P. LLORET and B. CAPIT *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 23 p Dec. 1986 In FRENCH
Avail: NTIS HC A15/MF A01

The coupling of inertial navigation methods with the Global Positioning System (GPS) is examined. The characteristics of various types of inertial systems are reviewed and past attempts at inertial/radionavigation hybridizations including those with multi- and VOR-DME (VHF omnidirectional range - distance measuring equipment), Transit, OMEGA, ILS (instrument landing systems), and altitude correlation are discussed. The possible configurations for an inertial/GPS systems, given the type (classical platform and strap-down) and classes of inertial designs and the number of GPS channels utilized, are defined and performance characteristics are outlined for each. Simulation and in-flight studies of prototype systems are discussed. Signal properties and Kalman filtering are addressed. Finally, perspectives on the continuing development of inertial/GPS hybrid systems are offered. M.G.

N87-21886# Aeronautical Radio, Inc., Annapolis, Md. Engineering Dept.
COMMUNICATION, NAVIGATION AND SURVEILLANCE SERVICES FOR THE AVIATION INDUSTRY USING SATELLITE TECHNOLOGY
R. A. PICKENS *In* AGARD Efficient Conduct of Individual Flights and Air Traffice or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 4 p Dec. 1986
Avail: NTIS HC A15/MF A01

A general historical survey of Communication Navigation, and Surveillance (CNS) services for the aviation industry using satellite technology is given. Aeronautical Radio, Inc's (ARINC) air-ground communications services, which consist of VHF voice and data transfer services, and HF voice communications are discussed. ARINC's implementation of an integrated satellite system and companion integrated avionics to provide air traffic control, company operational control, navigation capability for enroute operations, and support for cooperative operations is discussed. R.J.F.

N87-21887# Eurocontrol Agency, Brussels (Belgium).
POSSIBLE CONTRIBUTIONS FROM THE SSR MODE S DATA LINK TO THE CONDUCT OF EFFICIENT AIRCRAFT OPERATIONS
M. E. COX *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 15 p Dec. 1986
Avail: NTIS HC A15/MF A01

The paper entitled Data Link - The Key to Improvements in Civil Military Air Traffic Management?, presented at the Guidance and Control Panel (GCP) Symposium, Copenhagen, in October 1979, outlined a number of potential applications of a data link, then known as ADSEL/DABS, and referred to a number of feasibility studies that were being conducted in respect of these applications. Since that date the two systems (ADSEL/DABS) have led to the emergence of secondary surveillance radar (SSR) Mode S which is now being standardised for international use. Here, a brief description is given of the Mode S data link characteristics. A number of the applications proposed in 1979 are recalled and the results of studies conducted subsequently on such topics as the controller/pilot interfaces with the link and machine/machine data interchanges and their possible benefits to air traffic control (ATC) are given. Plans are discussed for more extensive data link evaluations. The initial steps that could be taken in progressing from today's situation towards a system of control employing a high level of automation are proposed.

N87-21891# Federal Aviation Administration, Atlantic City, N.J. Technical Center.
MICROWAVE LANDING SYSTEM (MLS) AREA NAVIGATION: COMPUTED CENTERLINE EXPERIMENTS AND SYSTEM ACCURACY ANALYSIS IN AN RF ENVIRONMENT
JAMES H. REMER and BARRY R. BILLMANN *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 17 p Dec. 1986
Avail: NTIS HC A15/MF A01

By definition of the International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPS) the Time Reference Scanning Beam (TRSB) Microwave Landing System (MLS) will supplant the existing Instrument Landing System (ILS) as the recognized international standard as early as 1995. Among numerous other advantages, the MLS provides the ability to determine the aircraft's position in three dimensional space over a large coverage volume in the airport terminal area. The use of this capability to navigate and execute approaches throughout this volume of coverage results from the application of a technique known as Microwave Landing System Area Navigation (MLS RNAV). Applications of MLS RNAV can be as simple as executing approaches offset from but parallel to the MLS 0 azimuth or as complex as multi-segment and curved path approaches. MLS RNAV is particularly adaptable to helicopter operations. It allows approaches to heliports located away from the main instrumented runway. In order to assess and further develop the potential capabilities of MLS RNAV, the FAA Technical Center has undertaken the task of performing analytical studies, as well as the development of a prototype MLS RNAV system. Applications of this system to helicopter operations are particularly being emphasized. The unique feature of this work is that besides the onboard data acquisition systems, an independent source of position information was, at times, available for comparison. The source was independent position tracking in the form of laser or radar data. The work reviewed here should have immediate application in the development of MLS RNAV Terminal Area Instrument Approach Procedures (TERPS).

N87-21892# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helipcopter and Military Aircraft Group.
MLS: ITS TECHNICAL FEATURES AND OPERATIONAL CAPABILITIES
R. SEIFERT *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 10 p Dec. 1986
Avail: NTIS HC A15/MF A01

Taking into account present developments in guidance and control automation in the airplane cockpit as well as in Air Traffic Control (ATC) systems, the following aspects of the Instrument Landing System/Microwave landing system (ILS/MLS) are analyzed and presented: (1) the complexity of MLS approach procedures and function allocation to ATC and aircraft; (2) cockpit automation and presentation of MLS approach information; and (3) aspects of all weather approach and landing with military aircraft. Author

N87-21893*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ADVANCED ATC: AN AIRCRAFT PERSPECTIVE
LEONARD CREDEUR, DAVID H. WILLIAMS, WILLIAM E. HOWELL, and CARY R. SPITZER *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 14 p Dec. 1986 Previously announced in IAA as A86-49637
Avail: NTIS HC A15/MF A01 CSCL 17G

The principal operational improvements desired by commercial aircraft operators in the United States are efficient aircraft operations and delay reductions at the major terminals. Efforts underway within the Advanced Transport Operating Systems Program at the Langley Research Center to provide a technology basis for reducing delay while improving aircraft efficiency are discussed. The principal thrust is the development of time-based traffic control concepts which could be used within the framework of the upgraded National Airspace System and which would allow conventionally equipped aircraft to operate in a manner compatible with advanced aircraft. Author

N87-21894# Consiglio Nazionale delle Ricerche, Rome (Italy). Progetto Finalizzato Trasporti and Istituto di Analisis dei Sistemi ed Informatica.
STRATEGIC CONTROL TO IMPROVE EFFICIENCY OF AIR TRAFFIC MANAGEMENT
LUCIO BIANCO *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 10 p Dec. 1986
Avail: NTIS HC A15/MF A01

The strategic control concept, intended as a new management philosophy that can improve efficiency of Air Traffic Control (ATC) systems, is discussed. After having introduced a classification of the different ATC functions based on a multilevel scheme, strategic control is decomposed in a hierarchy of sub-functions. Subsequently, the on-line strategic control of flights is considered and the mathematical aspects of this problem are illustrated. Then the structure of a real time solution algorithm, proposed in a previous work, and a possible scheme of route-time profile generation are reported. Finally, computational efficiency of the proposed approach is discussed. Author

N87-21895*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A TIME-BASED CONCEPT FOR TERMINAL-AREA TRAFFIC MANAGEMENT
HEINZ ERZBERGER and LEONARD TOBIAS *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 14 p Dec. 1986
Avail: NTIS HC A15/MF A01 CSCL 17G

An automated air-traffic-management concept that has the potential for significantly increasing the efficiency of traffic flows in high-density terminal areas is discussed. The concept's implementation depends on techniques for controlling the landing time of all aircraft entering the terminal area, both those that are equipped with on-board four-dimensional (4D) guidance systems as well as those aircraft types that are conventionally equipped. The two major ground-based elements of the system are a scheduler which assigns conflict-free landing times and a profile descent advisor. Landing time provided by the scheduler is uplinked to equipped aircraft and translated into the appropriate 4D trajectory by the-board flight-management system. The controller issues descent advisories to unequipped aircraft to help them achieve the assigned landing times. Air traffic control simulations have established that the concept provides an efficient method for controlling various mixes of 4D-equipped and unequipped, as well as low- and high-performance, aircraft. Piloted simulations of profiles flown with the aid of advisories have verified the ability to meet specified descent times with prescribed accuracy. Author

N87-21896# Federal Aviation Administration, Washington, D.C. Systems Engineering Service.
PHILOSOPHY OF APPLYING AUTOMATION TO AIR TRAFFIC CONTROL
LELAND F. PAGE *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 3 p Dec. 1986
Avail: NTIS HC A15/MF A01

The objectives of the U.S. program for applying automation to air traffic control systems, progress thus far, and plans for the future are discussed. Since the time in 1958 when computers were first used to print flight strips in the United States at a small number of air traffic control (ATC) centers, it has been a continuing objective to capitalize on the rapidly evolving computer technologies

to improve the ATC system. Specific objectives have been to apply computers and the associated automation functions to: improve safety of ATC operations; increase the efficiency of traffic management; and increase the productivity of ATC controllers.

Author

N87-21897# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Flugfuehrung.

COMPUTER ASSISTED ARRIVAL SEQUENCING AND SCHEDULING WITH THE COMPAS SYSTEM

U. VOELCKERS *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 11 p Dec. 1986

Avail: NTIS HC A15/MF A01

The Computer Oriented Metering Planning and Advisory System (COMPAS) developed at the DFVLR-Institute for Flight Guidance was tested and evaluated at the institute's air traffic simulation facility, using traffic scenarios of Frankfurt airport with up to 52 aircraft movements simultaneously. The operational objectives of the COMPAS-system are, with regard to Frankfurt airport, to achieve the best possible usage of the available but limited runway landing capacity, to avoid unnecessary delays and to apply economic approach profiles whenever possible. The planning functions which today are still carried out by human controllers will be transferred to a computer. It generates a comprehensive plan for a best overall arrival sequence and schedule. The execution of this plan, however, intentionally remains the task of the human controllers. They are provided with all data necessary to control the approaching aircraft. The systems concept, the dynamic planning algorithms as well as the operational concept for computer assistance and the man-machine interface are presented. Some preliminary results of the experiments and evaluation are reported.

Author

N87-21898# Eurocontrol Agency, Brussels (Belgium).

NEXT GENERATION OF CONTROL TECHNIQUES IN ADVANCED TMA

ANDRE BENOIT, SIP SWIERSTRA, and RENE DEWISPELAERE *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 31 p Dec. 1986

Avail: NTIS HC A15/MF A01

It is very likely that any future concept to be used for the safe and efficient conduct of air traffic (in terms of expedition, economy and capacity) will exhibit two essential, closely interrelated components. Firstly, the on-line management of air traffic over a large area - from a Zone of Convergence type to a continental coverage - will generate the landing and departure times for each aircraft entering the area, while at the same time defining the essential characteristics of the relevant flight paths. Secondly, an operational control procedure will be required to conduct each individual flight accurately throughout the area, that is to say, in the case of a Zone of Convergence, from entry to touchdown, in agreement with the air traffic management directives and in line with operational practice (onboard and on the ground). The essential operational features of a control procedure suitable to meet the above constraints while ensuring a 10-second accuracy for the time of arrival as predicted initially at entry into the zone (and possibly amended subsequently), for current air carriers in present R/T or future D/L communications environments are outlined.

Author

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EXPLOITING THE CAPABILITIES OF FLIGHT MANAGEMENT SYSTEMS IN SOLVING THE AIRPORT ARRIVAL PROBLEM

J. F. MEREDITH *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 10 p Dec. 1986

Avail: NTIS HC A15/MF A01

Increasingly Flight Management Computers are becoming standard fit on present day passenger aircraft (737-300, 757, 767, A310, A300-600). Avionic update programs which incorporate Flight Management Computers are in hand for 747 and MD 80 and new aircraft programs A320, MD 11, 7J7, A330 and A340 are or are likely to include Flight Management Computing as standard fit. As these aircraft come to dominate the traffic entering and leaving major airports there is potentially a new level of information and of control available to the air traffic controllers whose task it is to schedule the aircraft flow into and out of the terminal area. This information flow and the consequent control actions should enable the traffic to be handled in a manner to minimise delay, thus enhancing the available traffic handling capacity of an airport.

Author

N87-21900# Naval Air Development Center, Warminster, Pa.

APPLICATION OF FLIGHT PERFORMANCE ADVISORY SYSTEMS TO US NAVY AIRCRAFT

M. J. FRIEDMAN, L. J. COWLES, and R. C. CARSON, JR. *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Beneift of Civil and Military Airspace Users p 14 Dec. 1986

Avail: NTIS HC A15/MF A01

The U.S. Navy, in its Aircraft Energy Conservation Research and Development Program, is currently investigating various methods for improving the fuel efficiency of existing and future Navy aircraft. Fuel saving concepts under development include an aircraft integrated flight performance advisory system, a pre-flight mission planning program utilizing a desk type computer and an aircraft performance advisory system using an HP-41 CV hand-held calculator. The integrated flight performance advisory system for the F/A-18, the A-7E, and the S-3 are described in detail by reviewing the displayed outputs to the pilots and describing the required inputs and their sources. Features of each aircraft system are described in accordance with the development status of the program. The preflight mission planning program utilizing an HP-9845 desktop computer is described for the P-3C aircraft. The approach to weather, takeoff and cruise are described by specifying the input and output data. Sample displays are also shown. The hand-held HP-41 CV calculator utilized for flight performance predictions is described for the P-3C. All the calculator functions are described for the takeoff and cruise flight modes of this aircraft. The operational status of these three programs and plans for other Navy aircraft are also specified.

Author

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SEMI-AUTOMATIC CROSS-CHECKING BETWEEN DIFFERENT COPIES OF THE SAME FLIGHT PLAN

S. RATCLIFFE *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 7 p Dec. 1986

Avail: NTIS HC A15/MF A01

A flight-plan usually exists in several different forms in the aircraft flight management system: as hard copy on the flight-deck, in one or more Air Traffic Control/(ATC) data processors, and distributed over flight-progress strips (or their electronic equivalents) in one or more control centers. Any discrepancies between various versions of the plan are potentially hazardous. Given that the flight plan is already stored, for one reason or another, in at least one computer, it is proposed that each computer should also be used to generate a check word which can easily and rapidly be compared with that stored as hard-copy or in some other machine.

The check word might consist of four alpha characters which can easily be remembered and passed by voice. Possible algorithms for generating check-words are discussed. The results of some laboratory trials of a prototype system are given. Author

N87-21904# Civil Aviation Authority, London (England).
THE APPLICATION OF INTELLIGENT KNOWLEDGE BASED SYSTEMS TO AIR TRAFFIC CONTROL
W. S. NICOL, G. C. DEAN, A. JACKSON, and W. A. STRETTON (Royal Signals and Radar Establishment, Malvern, England) *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 9 p Dec. 1986
Avail: NTIS HC A15/MF A01

The need to explore the approach of Intelligent Knowledge Based Systems (IKBS) towards meeting the pressures for change in future air traffic control systems is discussed. The discussion includes the role of automation in air traffic control (ATC) and the suitability of IKBS within a shared approach between controller and machine. Areas selected to provide practical experience of IKBS applied to ATC include air traffic flow management and conflict resolution and training. Finally, guideline concepts for the introduction of a new technology to ATC are outlined. Author

N87-21905# Massachusetts Inst. of Tech., Lexington. Lexington Lab.
TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS) SURVEILLANCE PERFORMANCE IN HELICOPTERS
WILLIAM H. HARMAN, III, JERRY D. WELCH, and M. LOREN WOOD, JR. 8 May 1987 106 p
(Contract F19628-85-C-0002)
(DOT/FAA/PM-85/29; PROJ-REPT-ATC-135) Avail: NTIS HC A06/MF A01

Subsequent to the development of the Traffic Alert and Collision Avoidance System (TCAS) equipment for fixed-wing aircraft, a follow-on effort addressed the suitability of such equipment for use in helicopters. This program focused on those differences between helicopters and fixed-wing aircraft that might be expected to affect TCAS performance: the large rotor, the relatively irregular shape of the fuselage, the low speeds and high turn rates typical of helicopter flights, and the over-water and low-altitude conditions typical of helicopter operations. A Bell Long Range helicopter was acquired and equipped with experimental TCAS equipment with full data recording capability. Flight experiments were conducted to assess air-to-air surveillance performance under challenging conditions. Other flights involved guest pilots for subjective evaluations of the TCAS performance. It was concluded that the air-to-air surveillance techniques that were originally developed for use in large jet airliners will also perform satisfactorily in helicopters. It was also concluded that, because of the flight characteristics of helicopters, the pilot display should consist of traffic advisories alone, without resolution advisories. Author

N87-21906# National Aerospace Lab., Tokyo (Japan).
DEVELOPMENT AND FLIGHT VERIFICATION OF AIRBORNE GLIDESLOPE COMPUTATION/GUST DETECTION SYSTEM
TAKATSUGU ONO, MASAKI KOMODA, NAGAKATSU KAWAHATA, and YUKICHI TSUKANO 1986 26 p In JAPANESE; ENGLISH summary
(NAL-TR-908; ISSN-0389-4010) Avail: NTIS HC A03/MF A01

An airborne Glideslope Computation/Gust Detection System was developed for supporting flight tests of the National Aerospace Laboratory's Variable Stability and Response Airplane (VSRA). The system includes a set of Kalman filters to estimate position and inertial velocity and utilizes signals from the pressure altimeter, and accelerometers and gyros. Glideslope and localizer deviations from a preselected nominal flight path having an arbitrarily assigned glideslope angle, are computed and transmitted to ADI and HSI instead of the standard ILS signals. Gust components as differences of inertial and air speeds are also estimated. Based upon flight test data, estimated horizontal inertial speed is compared with that obtained from Doppler radar, and validity and accuracy of gust estimation are verified by state reconstruction techniques. Author

N87-22606*# Massachusetts Inst. of Tech., Cambridge. Flight Transportation Lab.
AIRCRAFT APPROACH GUIDANCE USING RELATIVE LORAN-C NAVIGATION
ANTONIO L. ELIAS *In* NASA. Langley Research Center Joint University Program for Air Transportation Research, 1984 p 9-16 May 1987
Avail: NTIS HC A08/MF A01 CSCL 17G

The experiments carried out at MIT during 1984 focussed on two aspects of Loran-C relative navigation that would impact system performance at the sub-microsecond level of accuracy: tracking loop bandwidth and localized field deformation. Figures are given to illustrate the results from both effects. E.R.

N87-22607*# Massachusetts Inst. of Tech., Cambridge.
PROBABILISTIC MODELING OF LORAN-C FOR NONPRECISION APPROACHES
JOHN K. EINHORN *In* NASA. Langley Research Center Joint University Program for Air Transportation Research, 1984 p 17-24 May 1987
Avail: NTIS HC A08/MF A01 CSCL 17G

The overall idea of the research was to predict the errors to be encountered during an approach using available data from the U.S. Coast Guard and standard normal distribution probability analysis for a number of airports in the North East CONUS. The research consists of two parts: an analytical model that predicts the probability of an approach falling within a given standard, and a series of flight tests designed to test the validity of the model. Author

N87-22612*# Ohio Univ., Athens.
LORAN-C APPROACH CONSIDERATIONS
ROBERT W. LILLEY *In* NASA. Langley Research Center Joint University Program for Air Transportation Research, 1984 p 61-63 May 1987
Avail: NTIS HC A08/MF A01 CSCL 17G

The use of Loran-C during approaches to landing is investigated. The Avionics Engineering Center has evaluated such approach applications at Galion, Ohio Municipal Airport and at Mansfield, Ohio Lahm airport. Loran-C data were referenced to ground tracker data to determine that the Loran-C approach path was straight, flyable, and parallel to the runway centerline. The Loran-C operational issues that were investigated are listed. Author

N87-22614*# Ohio Univ., Athens.
ADVANCED MONITORING CONCEPTS
ROBERT W. LILLEY *In* NASA. Langley Research Center Joint University Program for Air Transportation Research, 1984 p 69-71 May 1987
Avail: NTIS HC A08/MF A01 CSCL 17G

The emphasis in initial work will be on application of image processing techniques in the site monitoring of an ILS glide slope transmitting array. The glide slope requires a clear area in front of the antennas for use as a reflecting zone. Reflecting or scattering obstacles in this area can cause incorrect path formation and system outages. Direct video monitoring is impractical due to the narrow band nature of communication links from the ILS site to the regional maintenance location. Slow scan video is possible, but even this technique may require transmission of large amounts of data, tying up remote monitoring lines. The steps used to minimize data transmission are listed. Author

N87-22620*# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.
SAFE MICROBURST PENETRATION TECHNIQUES: A DETERMINISTIC, NONLINEAR, OPTIMAL CONTROL APPROACH
MARK L. PSIAKI *In* NASA. Langley Research Center Joint University Program for Air Transportation Research, 1984 p 139-148 May 1987
Avail: NTIS HC A08/MF A01 CSCL 17G

A relatively large amount of computer time was used for the calculation of a optimal trajectory, but it is subject to reduction with moderate effort. The Deterministic, Nonlinear, Optimal Control algorithm yielded excellent aircraft performance in trajectory tracking for the given microburst. It did so by varying the angle of attack to counteract the lift effects of microburst induced airspeed variations. Throttle saturation and aerodynamic stall limits were not a problem for the case considered, proving that the aircraft's performance capabilities were not violated by the given wind field. All closed loop control laws previously considered performed very poorly in comparison, and therefore do not come near to taking full advantage of aircraft performance. Author

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AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A87-35671
ROTORCRAFT INTEGRATION FOR IMPROVED MISSION COST EFFECTIVENESS
CRAIG SCOUGHTON (Allied-Bendix Aerospace, Flight Systems Div., Teterboro, NJ) Vertiflite (ISSN 0042-4455), vol. 33, Mar.-Apr. 1987, p. 12-16.

The integration of electronic systems on board modern military helicopters - to reduce the clutter and complexity of the proliferating black boxes commonly used to provide flight control, wide spectrum communications, precise navigation, threat protection, weapons guidance, cockpit instrumentation, obstacle/threat detection, and aircraft subsystem monitoring is examined. Basic system functions are noted that can be managed by integrated systems: the mission computer, remote terminal unit, display processor, crew station data entry, and crew station displays. System integration technologies currently under development include very-high-speed integrated circuitry, common modules, and the high-speed data bus. Examples of the more integrated approach are the advanced crew stations for the Boeing Model 360, the Air Force HH-60, the Army AHIP, and the joint service V-22. D.H.

A87-35673
HELICOPTER SYSTEMS INTEGRATION
HARRIS J. BELMAN (IBM Corp., Federal Systems Div., Owego, NY) Vertiflite (ISSN 0042-4455), vol. 33, Mar.-Apr. 1987, p. 24-27.

Systems integration makes it possible to create different mission-capable helicopters from one basic helicopter airframe, each with varying levels of avionics and mission capability. Experience as a systems integrator on major weapons systems is reported, most importantly as system prime contractor for the U.S. Navy's LAMPS MK III (Light Airborne Multi-Purpose System) ship/air weapon system, as avionics prime contractor for the U.S Air Force's HH/60A Nighthawk combat search and rescue helicopter, and as a participant in the U.S. Army's LHX (Light Helicopter Experimental) program. The status of the three programs from the avionics integration viewpoint is considered. The next generation of helicopters will include artificial intelligence-based systems, for such functions as maintenance/self-diagnostics, tactical planning, and sensor fusion. D.H.

A87-35674
LANDING GEAR - A COMPLETE SYSTEMS APPROACH
R. F. DARLINGTON (Dowty Canada, Ltd., Ajax) Vertiflite (ISSN 0042-4455), vol. 33, Mar.-Apr. 1987, p. 32-34.

The program to develop and manufacture the landing gear for the V-22 Osprey is described. The system is a twin-wheel cantilevered main landing gear that retracts rearward. It is fuselage mounted and designed for a normal vertical velocity landing requirement of up to 12 feet per second with a 14.7 feet per second hard landing condition. It is designed to withstand a 24 feet per second carrier landing. Included in the design and manufacturing program are systems synthesis, major components, steering and controls; electronic modules and packaging; actuators, shuttle valves, and hydraulic fuses; and support, repair and overhaul. The landing gear itself is considered to include shock struts, side or drag braces, retraction and extension mechanisms, up and down locks, door actuation, steering actuation with shimmy damping capability, steering and landing gear electronic control, electrical harnesses and hydraulic plumbing attached to the landing gear, and all indication switches for locks and steering limits. A variety of cockpit-located subsystems are now considered to be included. Computer modeling so as to minimize the necessary weight of the landing gear is discussed. D.H.

A87-35675
TEST FLYING THE CYCLO-CRANE 'PROOF-OF-CONCEPT' EXPERIMENTAL MODEL N240AL
J. J. MORRIS (Aerolift, Inc., Tillamook, OR) Vertiflite (ISSN 0042-4455), vol. 33, Mar.-Apr. 1987, p. 40-50.

The Cyclo-Crane hybrid aircraft concept and recent flight test results of the proof-of-concept model are presented. The structure is designed so that the net aerostatic lift of the helium in the aerostat is equal to the sum of all structural weight and 50 percent of the design slingload weight. The balance of lift for the design slingload weight and thrust for control and transition is created by the aerodynamic lift of the external airfoils. The test aircraft has an overall length of 178 feet, aerostat diameter and length of 68 feet and 136 feet respectively, and lift capacity of 4000 pounds. The pilot has a set of helicopter type controls which allow him to pitch and yaw the aircraft and translate along each of the three axes. When the aircraft is in a hover mode, the wings are positioned parallel to the shaft on which the centerbody rotates, providing lift via cyclic control, enabling the Cyclo-Crane to ascend and descend vertically and move laterally. Among the topics covered are: requisite instrumentation, preparation for tests, control feel, operation in winds, and operational safety. The first operational Cyclo-Crane is to have a 35- to 45-ton payload capacity. D.H.

A87-36276
ADHESIVELY SEALED FUEL TANKS - R&D TO PRODUCTION
FRED W. AULD (General Dynamics Corp., Fort Worth, TX) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 11 p.
(SAWE PAPER 1688)

As a result of a program funded by the Air Force on adhesively sealed fuel tanks for Air Force jets, a production manufacturing change is being implemented for the F-16 multinational fighter. After General Dynamics manufactured almost 1600 aircraft using a conventional integral fuel tank sealing system, it has begun producing F-16 fuel tanks with a new thermo-setting nitrile phenolic adhesive sealing system, instead of the old polysulfide sealing system. The advantages offered by this sealing system - weight reduction and improved fuel tank sealing - along with the successful implementation of the change at a mid-production breakpoint on the F-16 program are expected to lead to this sealing system being considered for future company programs. D.H.

A87-36280
THE COST EFFECTIVENESS OF WEIGHT REDUCTION BY ADVANCED MATERIAL SUBSTITUTION
PAUL W. SCOTT (Douglas Aircraft Co., Long Beach, CA) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 17 p.
(SAWE PAPER 1693)

Generalized relationships are derived to analyze the cost effectiveness of weight reduction obtained by substitution of an advanced material of reduced density with no change in dimensions. The relationships are applied to a preliminary assessment of aluminum-lithium on an advanced derivative of the MD-80 transport aircraft. This parametric method provides a greater visibility on the material cost considerations than a case-by-case approach, but nonrecurring costs must be omitted. To obtain a better understanding of the material utilization parameter, 70 production aircraft components fabricated from plate, sheet, extrusions, conventional forgings, and precision forgings are analyzed. With reduced cost premiums and improved utilization, many components fabricated from plate, heavily machined extrusions, and conventional forgings could become cost effective applications for Al-Li. The net value of the weight reduction provided by applications with low material utilization, however, will be significantly offset by the added material expense. Material utilization data are tabulated for MD-80 and DC-10/KC-10 aircraft structural elements. D.H.

A87-36289
GULFSTREAM CORPORATE AIRCRAFT DESIGN EVOLUTION THROUGH THE MODEL GULFSTREAM IV
MICHAEL F. VIAFORA, JR. (Gulfstream Aerospace Corp., Savannah, GA) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 35 p.
(SAWE PAPER 1717)

The history of the various Gulfstream models of corporate aircraft, from the first flight of the Gulfstream I in 1958 to the present, is outlined. Of the 200 twin-prop Gulstream I's that were produced, 194 are still flying today. The twin Rolls-Royce turbofan Gulfstream II was designed and first flown in the 1960s. In 1975, it became apparent that the increased demand for international business flying had created a need for an aircraft with more capability, so the Gulfstream III was developed (Maximum cruise speed: Mach 0.85, NBAA/IFR range: 3600 nautical miles). Design and development work on the Gulfstreaam IV during the period from 1982 to 1985 is described, with emphasis on weight-saving through redesign and the use of influencing demand for the various aircraft, design philosophies, and aircraft characteristics and performance summaries. D.H.

A87-36291
OPERATING COSTS OF TRANSPORT AIRPLANES - INFLUENCE OF THE WING ASPECT RATIO AND FLIGHT CONDITIONS
PIERO A. GILI and FULVIA B. QUAGLIOTTI (Torino, Politecnico, Turin, Italy) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 23 p. refs
(SAWE PAPER 1720)

Taking as inputs the data relevant to a particular class of jet aircraft (maximum weight, wing area, and available thrust), a program is used to determine the direct operating costs (DOCs) as a function of the wing aspect ratio. All direct costs (as for fuel) are related to weight of payload carried per kilometer; DOCs considered include: equipped airframe depreciation and interest, engine system depreciation and interest, aircraft insurance, components maintenance, airframe maintenance, engine system maintenance, crew, lubricants, landing fees and handling. Sample results obtained are presented in parametric form in diagrams not only to show the interaction of the quantities involved (including their pattern of variation) but also to permit the easy identification of optimum values. Minor modifications in the program would enable the method to be used for propeller aircraft as well as jets. D.H.

A87-36298
X-WING - AN AIRCRAFT FOR THE 21ST CENTURY
JOHN G. SUTTON and ANTHONY C. SAWICKI (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 19 p.
(SAWE PAPER 1732)

The X-wing concept offers the potential of being the first VTOL concept to provide efficient hover performance and fixed wing flight cruise speed (to Mach 0.8) without the weight penalties associated with dual lift systems. The X-wing is a four bladed, extremely rigid rotor/wing which can be started and stopped in flight and uses circulation control blowing (Coanda effect) to produce lift and control. The concept has been under development for over 15 years and has reached the flight test hardware stage. Current and emerging technologies provide the basis for X-wing air vehicles to be competitive in both weight empty fraction and payload/range. An X-wing aircraft has the potential of meeting and exceeding the requirements of many U.S. Navy missions. Anticipated in-service date for production aircraft would be approximately the year 2000. D.H.

A87-36299
NOTAR HELICOPTER - A NEW APPROACH TO HELICOPTERS
ANDREW LOGAN and KRISHAN KUMAR (McDonnell Douglas Helicopter Co., Mesa, AZ) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 14 p. refs
(SAWE PAPER 1734)

Development and flight test work have been conducted with regard to the NOTAR (NO TAil Rotor) helicopter concept, and the concept has been shown to be a viable alternative to the tail rotor. The NOTAR system combines circulation control along the tailboom with a direct jet thruster to provide the required antitorque and maneuvering forces in all flight regimes. A variable pitch fan is mounted inside the fuselage and is driven from the main rotor gearbox; the fan blows low pressure air axially along the tailboom, providing both circulation control and the direct jet. The handling qualities have been shown to be exceptionally smooth due to the absence of tail rotor disturbances. Continued design development has shown that NOTAR can provide the anticipated operational, life cycle cost, safety, and acoustic benefits by eliminating the tail rotor on the next generation of rotorcraft. Author

A87-36300
AVIONICS WEIGHT CONTROL FOR THE STARSHIP AND BEYOND
TERRY D. CANNING (Rockwell International Corp., Avionics Group, Cedar Rapids, IA) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 19 p.
(SAWE PAPER 1736)

The design program leading to the avionics systems for the Beechcraft Starship 1 (Model 2000) is described. The Starship is a high-performance, ten-passenger aircraft with twin Pratt and Whitney Canada PT6A-67 engines in a pusher configuration. Development of the aircraft presented an opportunity to address a problem of avionics weight control: avionics weight has grown in turboprops and business jets over the past decades to as much as 7 percent of the aircraft weight. Six goals were addressed in the Starship avionics development program: improved performance, weight reduction, volume reduction, reduction in wiring, reliability enhancement, and simplified cockpit operation. By usine new concepts of packaging - particularly surface-mounted devices and gate arrays - and integration of functions, it has been possible to reduce installed volume of avionics by 57 percent and installed weight by 60 percent. The resulting integrated control/display unit, radio tuning unit, and weather radar system are illustrated. D.H.

A87-36302
STAYING AHEAD IN MARITIME PATROL
WILLIAM M. CHILDERS (Lockheed-California Co., Burbank) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 18 p.
(SAWE PAPER 1738)

This paper presents an analysis of the requirements for the land-based maritime patrol aircraft of the future. A discussion of the antisubmarine warfare mission, both present and future, leads to definition of the aircraft needed to fulfill this mission into the next century. Possible sources for this aircraft are considered. Based upon the assumption that a derivative of the current maritime patrol aircraft would be the most cost-effective source for the new aircraft, an analysis of the weight increments associated with incorporating new capabilities into the current airplane is presented. Particular attention is given to determining an acceptable solution to a need for expanded center of gravity limits. Two derivative aircraft are defined: one which retains the same external size of the current airplane and another which is increased in both length and span. Author

A87-36305
FIFTEEN YEARS OF FLIGHT CONTROL EVOLUTION ON EUROPEAN AIRBUS AIRCRAFT WEIGHT IMPACT
M. HAMMEN (Aerospatiale, Toulouse, France) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 25 p. refs
(SAWE PAPER 1743)

The evolution of aircraft controls from the strictly mechanical/hydraulic type to the advanced 'fly-by-wire' concept now applied to the Airbus A320 is considered. The evolutionary process began with the A310 and A300-600 aircraft which had some electrical secondary flight control; experience gained with the initial fly-by-wire system on the Concorde has been applied on the Airbus A320; with improvements mainly made possible by the progress in the field of electronic and airborne computers. The A320 now has electric primary pitch and roll controls and has introduced a side-stick controller. This evolution has permitted a direct weight savings of about 30 percent of the total flight control weight; indirect weight benefits appear on the wing structure due to load alleviation and in flight deck layout because conventional control columns can be removed. The future promises additional evolutionary developments as a result of research on electrical power servo actuators and fully electric flight controls. D.H.

A87-36699
F-15E - HEAVYWEIGHT EAGLE
BILL SWEETMAN Interavia (ISSN 0020-5168), vol. 42, March 1987, p. 262, 263.

The design modifications and performance gains projected for the F-15E development variant of the Eagle series of air superiority fighters are presented. The F-15E is intended to excel not only in the air superiority role, but that of all-weather interdiction/strike aircraft, as well; to this end, it has incorporated a second crewmember (weapon system operator), an additional 892 lb of internal fuel capacity, and six more external weapons carriage hardpoints along the lower surface of the conformal fuel tanks. The F-15E is able to deliver weapons in air-to-ground mode while maneuvering, by means of a flight control/fire control system which blends pilot inputs with those generated by a target tracking error-correction computer which employs data from radar and other sensors. The F-15E's design payload/range performance now approximates that of the F-111 series aircraft. O.C.

A87-36765
THE INFLUENCE OF INFLATION RATES AND FUEL PRICES ON OPTIMIZED AIRCRAFT DESIGN [DER EINFLUSS VON TEUERUNGSRATEN UND KRAFTSTOFFPREISEN AUF DEN OPTIMIERTEN FLUGZEUGENTWURF]
H. KOSSIRA and H. POHL (Braunschweig, Technische Universitaet, Brunswick, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 112-121. In German. refs
(DGLR PAPER 86-110)

A two-phase program developed for aircraft design optimization is presented in the form of flow diagrams. In the first phase, the aircraft is considered as a point mass in order to preoptimize a number of design parameters with relatively simple computational procedures and affordable expense and to recognize secondary minima. The resulting values are used in the second phase to determine the optimal aircraft geometry, component masses, and final values of the design parameters. This optimization program is used to study the effects of boundary conditions on the aircraft design. The opposing influences of fuel costs and capital costs, as well as those of landing fees and crew costs, on the optimal design are shown. C.D.

A87-36767
DESIGN OF A TWO-SEATER TRAINING AIRCRAFT WITH PROPELLER TURBINES [ENTWURF EINES ZWEI-SITZIGEN TRAININGSFLUGZEUGES MIT PROPELLERTURBINE]
F. SIDAN (Stuttgart, Universitaet, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 128-137. In German.
(DGLR PAPER 86-127)

A training aircraft for beginning pilots of the Turkish air force has been developed. The aerodynamic and static design, the system design, and selection of the propeller and engine types, the determination of the weight and stability, and the determination and optimization of the aircraft performance and the three-sided profile are described. These determinations involved the use of finite element and panel methods. C.D.

A87-36771
A QUASI-STATIONARY CALCULATION MODEL FOR SIMULATING HELICOPTER STARTING AND LANDING PROCEDURES WITH EMPHASIS ON THE GROUND EFFECTS [EIN QUASISTATIONAERES RECHENMODELL MIT BERUECKSICHTIGUNG DES BODENEFFEKTS ZUR SIMULATION VON START- UND LANDEVORGAENGEN VON HUBSCHRAUBERN]
THOMAS CERBE (Braunschweig, Technische Universitaet, Brunswick, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 171-183. In German. refs
(Contract DFG-SFB-212)
(DGLR PAPER 86-152)

In this paper, starting and landing procedures for helicopters are simulated using a quasi-stationary model, and the results are reported. The existence and nature of critical points during landing and takeoff are demonstrated, and the determination of power excess or deficit during starting and landing is considered. The results for selected procedures are compared with flight test results of an actual helicopter. C.D.

A87-36772
EXTENSION OF A COMPUTER-SUPPORTED PROCEDURE FOR HELICOPTER-DESIGN GENERATION [ERWEITERUNG EINES RECHNERGESTUETZTEN VERFAHRENS ZUR HUBSCHRAUBER-ENTWURFSSYNTHESE]
P. SCHWARTZ (Muenchen, Universitaet der Bundeswehr, Munich, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 184-191. In German.
(DGLR PAPER 86-153)

A performance and mission determination program for comparing the performance of competing helicopters with regard to particular mission requirements has been developed. The trim determination is discussed, including the design of the rotors, fuselage, steering assembly, and engines. The evaluations resulting from simulated missions are addressed along with the method of determining necessary improvements. C.D.

A87-36789
DETERMINATION OF THE FLIGHT PERFORMANCE OF THE HYBRID AIRCRAFT HELITRUCK [BERECHNUNGEN DER FLUGLEISTUNGEN DES HYBRIDFLUGZEUGES HELITRUCK]
STEFAN LEVEDAG (Darmstadt, Technische Hochschule, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 312-316. In German.
(DGLR PAPER 86-144)

Calculations of the flight performance of the hybrid aircraft concept Helitruck are presented. It is shown that, with regard to wing-wing and propeller-wing interference, the set of mechanical equations describing the undisturbed longitudinal motion in simplified form is suitable for giving the resistance characteristic in the form of a parabolic polar curve when freely alterable configuration parameters are adapted to minimal total thrust requirements. The engine performance and the static thrust are described as functions of height and flight speed, and diagrams are shown comparing the performance and range of the hybrid aircraft concept with that of existing VTOL concepts. C.D.

A87-36795
THE INFLUENCE OF THREE-DIMENSIONAL COMPUTER-ASSISTED DESIGN SYSTEMS (CAD) ON THE DESIGN OF FUTURE HELICOPTERS [EINFLUESSE DREIDIMENSIONALER RECHNERGESTUETZTER KONSTRUKTIONSSYSTEME (CAD) AUF DEN ENTWURF ZUKUENFTIGER HUBSCHRAUBER]
W. HALAMEK (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 362-367. In German.
(DGLR PAPER 86-168)

The use of three-dimensional CAD in helicopter design is discussed, and typical results of such application are described. The resulting helicopter outline, subsystem integration, and cockpit design are considered, presenting illustrations. The use of three-dimensional CAD in the kinematic study of helicopters is examined. The advantages of three-dimensional CAD over two-dimensional CAD are emphasized throughout. C.D.

A87-38697#
HELICOPTER STRUCTURAL CRASHWORTHINESS
J. D. CRONKHITE (Bell Helicopter Textron, Fort Worth, TX) IN: Symposium on Vehicle Crashworthiness Including Impact Biomechanics; Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 57-73. refs

The present evaluation of critical design parameters, energy absorbing structure concepts, crash analysis methods for helicopter airframes and published helicopter crash environment studies notes significant differences between civilian and military helicopter crashes, especially in the case of vertical impacts. A relatively small percentage of helicopter crashes occurs on hard, level surfaces; the greater portion occurs on soft soil. Attention is given to airframe structures incorporating an energy-absorbing fuselage underfloor, which have been demonstrated by NASA and U.S. Army full scale structure testing. Correlation results using the KRASH computer program are discussed. O.C.

A87-38706#
AIRCRAFT FOG CONTROL SYSTEMS
DAN S. MATULICH (AiResearch Manufacturing Co., Torrance, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 41-50.
(SAE PAPER 860914)

While several methods have been used to control fog on aircraft windows, the most common are electrical and pneumatic. Most of the high performance military aircraft, for which fog control requirements are most severe, use pneumatic systems. These systems may use bleed or ram air, or may use conditioned air from the aircraft environmental control system (ECS). With the introduction of high-pressure water extraction in the aircraft ECS, extremely dry air has become available for fog control. This allows increased design flexibility, making antifog systems, which operate continuously to prevent fog formation, more practical. Author

A87-39080#
THEORETICAL FOUNDATIONS OF A METHOD FOR THE STRENGTH ANALYSIS OF FUSELAGE FRAMES [TEORETICHESKIE OSNOVY METODA RASCHETA NA PROCHNOST' SHPANGOUTOV AVIAKONSTRUKTSII TIPA FIUZELIAZHA]
IU. V. VASIL'EV and OL'GA I. MARTIN Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 31, Nov.-Dec. 1986, p. 647-666. In Russian.

A method for the strength analysis of fuselage frames is developed which is based on the minimum principle of additional potential strain energy of the elastic system considered. The calculation model is composed of a finite number of elements into which is divided the half of the frame that is symmetric with respect to the vertical axis. A functional is derived for the additional potential strain energy of the system, expressed through forces and moments in the elements of the calculation model; the overall stress state is divided into symmetric and asymmetric components, which are examined separately. The solution is obtained via the CADRO program. B.J.

A87-39085#
THEORETICAL FOUNDATIONS OF A METHOD FOR THE STRENGTH ANALYSIS OF FUSELAGE FRAMES. II - SOLUTION OF THE ENERGY PROBLEM [TEORETICHESKIE OSNOVY METODA RASCHETA NA PROCHNOST' SHPANGOUTOV AVIAKONSTRUKTSII TIPA FIUZELIAZHA. II - RESHENIE ENERGETICHESKOI ZADACHI]
IU. V. VASIL'EV and OL'GA I. MARTIN (Institutul National Pentru Creatie Stiintifica si Tehnica, Bucharest, Rumania) Revue Roumaine des Sciences Techniques, Serie de Mecanique Appliquee (ISSN 0035-4074), vol. 32, Jan.-Feb. 1987, p. 103-119. In Russian. refs

The theoretical principles behind an energy method for the strength analysis of transverse stiffeners for fuselages are formulated. The potential energy functional of the system is derived along with the resolvent equations. The stress-state characteristics and the safety margin are determined. B.J.

A87-39146#
AERO-MARINE DESIGN AND FLYING QUALITIES OF FLOATPLANES AND FLYING-BOATS
DARROL STINTON (Darrol Stinton, Ltd., Farnham, England) Aeronautical Journal (ISSN 0001-9240), vol. 91, March 1987, p. 97-127. refs

A comprehensive account is given of the development history of seaplane and amphibious aircraft design, with attention to the design practices that have been formulated on the basis of accumulated experience and the performance capabilities and limitations that are characteristic of this type of aircraft. While the early development of floatplanes and flying-boats was dominated by racing aircraft and large passenger carriers, more recent designs have successfully concentrated on such specialized applications as search-and-rescue, antisubmarine warfare, and water-skimming tank-refill 'water bombing' for forest fire dousing. The primary design problem presented by flying boats is the reconciliation of aerodynamic criteria with hydrodynamic ones; a rather substantial reduction in ideal cruise flight efficiency is the inevitable result of water landing capabilities. O.C.

N87-21907# Boeing Military Airplane Development, Seattle, Wash.
FAULT TOLERANT ELECTRICAL POWER SYSTEM. PHASE 2: ANALYSIS AND PRELIMINARY DESIGN Interim Report, 1 Jul. 1985 - 31 Mar. 1986
MARK W. DIGE, PATRICK J. LEONG, and DAVID L. SOMMER Dec. 1986 188 p
(Contract F33615-85-C-2504)
(AD-A177278; D180-28576-3; AFWAL-TR-86-2084-2) Avail: NTIS HC A09/MF A01 CSCL 10B

The primary purpose of the program is to develop an electrical power generation and distribution system that can supply electrical power to the various critical systems on the aircraft with a reliability and power quality level commensurate with the requirements of the loads. Phase 2 consisted of 4 tasks: Task 1-FTEPS Demonstrator Basic Requirements, Task 2-Analysis, Task 3-FTEPS Demonstrator Conceptual Design, and Task 4-FTEPS Demonstrator Preliminary Design. In Task 1, the basic fault and reliability requirements of the system were developed and a load profile was established for the baseline aircraft. Task 2 activities included development of specific system requirements and reliability analysis of power delivered to the main power buses of different architectures. A data bus analysis was performed on an integrated single data bus and an integrated hierarchical data bus. The hierarchical data bus was selected for the FTEPS. In Task 3, conceptual designs were developed for a 3 generator configuration and a 4 generator configuration with the 4 generator configuration being selected for further development in Task 4, Preliminary Design. Preliminary designs were developed for the power generator system, the distribution system, the data bus control system, the integrated load simulator and a laboratory support system. GRA

N87-21908*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
FLIGHT TEST TECHNIQUES FOR THE X-29A AIRCRAFT
JOHN W. HICKS, JAMES M. COOPER, JR., and WALTER J. SEFIC Feb. 1987 14 p Presented at the AIAA 25th Aerospace Sciences Meeting, Reno, Nev., 12-15 Jan. 1987 Previously announced in IAA as A87-22403
(NASA-TM-88289; H-1401; NAS 1.15:88289; AIAA-87-0082)
Avail: NTIS HC A02/MF A01 CSCL 01C

The X-29A advanced technology demonstrator is a single-seat, single-engine aircraft with a forward-swept wing. The aircraft incorporates many advanced technologies being considered for this country's next generation of aircraft. This unusual aircraft configuration, which had never been flown before, required a precise approach to flight envelope expansion. This paper describes the real-time analysis methods and flight test techniques used during the envelope expansion of the x-29A aircraft, including new and innovative approaches. Author

N87-21911# Air War Coll., Maxwell AFB, Ala.
AUGMENTOR WING POWERED LIFT TECHNOLOGY: AFFORDABLE ALTERNATIVES TO ENHANCE TACTICAL AIRLIFT CAPABILITY
JOHN E. MCGEE May 1986 135 p
(AD-A177750; AD-E751201; AU-AWC-86-143) Avail: NTIS HC A07/MF A01 CSCL 01C

Remarks on the status and capabilities of Augmentor Wing (AW) powered lift technology introduce a discussion of potential Air Force needs satisfaction in a variety of affordable aircraft applications. A description of technology capabilities and cost comparison examples complete the background for the author's view on current and future air force inter- and intra-theater tactical airlift operational and program benefits from this technology. Competing technologies and AW applications on Short Take-Off Vertical Land (STOVL) tactical and strategic airlifters and the adaptation of Ejector Lift/Vertical Thrust (EL/VT) technology to an advanced pilot trainer aircraft and a Supersonic Short Take-Off Vertical Land (SSTOVL) fighter, as in the Advanced Tactical Fighter (ATF) and Advanced/Short Take Off Vertical Land (A/STOVL) aircraft are discussed. International development of a joint technology demonstrator and a next generation tactical airlifter to meet United States, Canadian, United Kingdom, West German, French, Australian and other allied requirements is suggested. GRA

N87-21913# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
IDENTIFICATION OF DYNAMIC SYSTEMS - APPLICATIONS TO AIRCRAFT. PART 1: THE OUTPUT ERROR APPROACH
R. E. MAINE and K. W. ILIFF Dec. 1986 187 p
(AGARD-AG-300-VOL-3-PT-1; ISBN-92-835-1540-4; AD-A178766)
Avail: NTIS HC A09/MF A01

This document examines the practical application of parameter estimation methodology to the problem of estimating aircraft stability and control derivatives from flight test data. The primary purpose of the document is to present a comprehensive and unified picture of the entire parameter estimation process and its integration into the flight test program. The document concentrates on the output-error method to provide a focus for detailed examination and to allow us to give specific examples of situations that have arrisen in our experience. The document first derives the aircraft equations of motion in a form suitable for application to estimation of stability and control derivatives. It then discusses the issues that arise in adapting the equations to the limitations of analysis programs, using a specific program for an example. The document then addresses the roles and issues relating to mass distribution data, preflight predictions, maneuver design, flight scheduling, instrumentation sensors, data acquisition systems, and data processing. Finally, the document discusses evaluation and use of the analysis results. Author

N87-21915*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ANALYSIS OF THE FREE-TIP ROTOR WIND-TUNNEL TEST RESULTS
ROBERT H. STROUB May 1985 70 p
(NASA-TM-86751; REPT-85236; NAS 1.15:86751) Avail: NTIS HC A04/MF A01 CSCL 01C

The results from a wind tunnel test of a small scale free-tip rotor are analyzed. The free-tip rotor has blade tips that are free to weathervane into the tip's relative wind, thus producing a more uniform lift around the azimuth. The free-tip assembly, which includes the controller, functioned flawlessly throughout the test. In a test of the free-tip's response after passing through a vertical air jet, the tip pitched freely and in a controlled manner. Analysis of the tip's response characteristics showed the free-tip system's damped natural frequency to be 5.2 per rev. Tip pitch angle responses to the local airstream are presented for an advance-ratio range of 0.1 to 0.397 and for a solidity weighted rotor lift coefficient range of 0.038 to 0.092. Harmonic analysis of the responses showed a dominance by the first harmonic. As a result of the tip

being free, forward flight power requirements were reduced by 8% or more. More power reduction was recorded for high thrust conditions. In addition to the power reduction, flatwise blade bending moments were reduced by as much as 30% at the inboard blade stations. Author

N87-21916# National Aerospace Lab., Tokyo (Japan).
TRANSONIC AIRFOIL DESIGN BASED ON THE NAVIER-STOKES EQUATIONS TO ATTAIN ARBITRARILY SPECIFIED PRESSURE DISTRIBUTION: AN ITERATIVE PROCEDURE
NAOKI HIROSE, SUSUMU TAKANASHI, and NOBUHIRO KAWAI Mar. 1986 18 p
(NAL-TR-901T; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

An iterative procedure for transonic airfoil design based on the Navier-Stokes equations to attain arbitrarily specified pressure distributions is proposed. A transonic integral equation for the inverse problem for the correction term between the basic pressure distribution and the specified pressure distribution is formulated and is combined with a time-averaged Navier-Stokes airfoil analysis code. Shock wave and viscous effects including weak separation are properly evaluated in the analysis mode and therefore are effectively incorporated in the design procedure. Numerical results for a shockless pressure distribution and a supercritical pressure distribution are presented. A small number of iterative steps yield almost satisfactory airfoil geometry from a practical point of view. The method is also applied to low speed airfoil designs and the results are shown. Author

N87-21917*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FUEL PENALTIES AND TIME FLEXIBILITY OF 4D FLIGHT PROFILES UNDER MISMODELED WIND CONDITIONS
DAVID H. WILLIAMS Mar. 1987 28 p
(NASA-TM-89128; NAS 1.15:89128) Avail: NTIS HC A03/MF A01 CSCL 01C

A parametric sensitivity study was conducted to evaluate time flexibility and fuel penalties associated with 4D operations in the presence of mismodeled wind. The final cruise and descent segments of a flight in an advanced time-metered air traffic control environment were considered. Optimal performance of a B-737-100 airplane in known, constant winds was determined. Performance in mismodeled wind was obtained by tracking no-wind reference profiles in the presence of actual winds. The results of the analysis are presented in terms of loss of time flexibility and fuel penalties compared to the optimum performance in modeled winds. Author

N87-22344*# Douglas Aircraft Co., Inc., Long Beach, Calif.
NEW GENERATION AIRCRAFT DESIGN PROBLEMS RELATIVE TO TURBULENCE STABILITY, AEROELASTIC LOADS AND GUST ALLEVIATION
RICHARD M. HEIMBAUGH *In* NASA. Langley Research Center Atmospheric Turbulence Relative to Aviation, Missile and Space Programs p 27-45 Apr. 1987
Avail: NTIS HC A12/MF A01 CSCL 01C

Past history, present status, and future of discrete gusts are schematically presented. It is shown that there are two approaches to the gust analysis: discrete and spectral density. The role of these two approaches to gust analysis are discussed. The idea of using power spectral density (PSD) in the analysis of gusts is especially detailed. E.R.

N87-22666# Italian Air Staff, Rome.
SOME DEVELOPMENT TRENDS IN LIGHT GROUND ATTACK AIRCRAFT
R. TONINI, G. M. AVAGNINA, E. LOJACONO, and N. BRAGAGNOLO (Aeritalia S.p.A., Caselle Torinese, Italy) *In* AGARD Improvement of Combat Performance for Existing and Future Aircraft 16 p Dec. 1986
Avail: NTIS HC A07/MF A01

The development of a light bomber attack aircraft, AM-X, is discussed. Specific design requirements and cost effectiveness, a mission effectiveness model, effectiveness tradeoffs, weapon systems and avionics are among the topics surveyed. R.J.F.

N87-22668# British Aerospace Public Ltd. Co., Kingston-upon-Thames (England). Aerodynamics Dept.
EVOLUTION OF COMBAT PERFORMANCE OF THE HAWK LIGHT COMBAT AIRCRAFT
S. F. STAPLETON and R. S. DABBS *In* AGARD Improvement of Combat Performance for Existing and Future Aircraft 11 p Dec. 1986
Avail: NTIS HC A07/MF A01

The progressive evolution of the BAe Hawk from its original concept as the advanced flying trainer aircraft for the RAF to the currently planned developments as a light attack aircraft is reviewed. The developments are described in aerodynamics propulsion and systems to give improvement in performance and weapon delivery capability appropriate to effective light attack operational roles. Author

N87-22669# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany). Helicopter and Airplane Div.
INTEGRATED DESIGN OF STRUCTURES
O. SENSBURG, G. SCHMIDINGER, and K. FUELLHAS *In* AGARD Improvement of Combat Performance for Existing and Future Aircraft 20 p Dec. 1986
Avail: NTIS HC A07/MF A01

It is shown that for highly sophisticated, naturally unstable airplanes flying supersonically a joint strategy to lay out the flight control system while minimizing design loads must be adopted. The selection of control surface geometry must be performed utilizing all possibilities from overall structural optimization including aeroelastic tailoring for primary carbon fiber structures. In the proposed design philosophy the behavior of the elastic airplane structure must be introduced and optimized in the very early design stage. It is shown that the required control surface hinge moments can be reduced by optimizing mass penalties and efficiencies. Minimizing installed hydraulic power supply has also a beneficial effect on engine performance at low speed, high altitudes. Author

N87-22675# British Aerospace Public Ltd. Co., Lancashire (England). Military Aircraft Div.
THE ASSESSMENT AND EVALUATION OF COMBAT PERFORMANCE IMPROVEMENTS
A. G. BARNES *In* AGARD Improvement of Combat Performance for Existing and Future Aircraft 8 p Dec. 1986
Avail: NTIS HC A07/MF A01

Aircraft performance improvements, for combat or any other operational role, are becoming increasingly difficult to achieve. The dramatic year-by-year advances of the forties and fifties are long gone. Aerodynamicists have a much better understanding of the physical properties of the atmosphere and the shapes which can best be propelled through it. The relationships between the energy in fuel, and the conversion process into thrust are well developed. Structural engineers understand the mechanical properties of materials needed to build engines and airframes. All these factors have been exploited, and further improvements do not come cheaply. Only in the area of avionics can it be said that large benefits in the weight/cost/performance trade-off can be expected. The use of mathematical models, current simulation capabilities, tradeoff studies, and operational tactics are discussed. Author

N87-22676# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
ACCURATE PREDICTION OF LONGITUDINAL FLYING QUALITIES FOR LANDING AIRCRAFT M.S. Thesis
JAMES J. MARTZ Dec. 1986 143 p
(AD-A179069; AFIT/GAE/ENG/87M-1) Avail: NTIS HC A07/MF A01 CSCL 01B

A new longitudinal flying qualities metric, called Loop Separation Parameter (LSP), is intended to correlate with pilot opinion ratings for the landing task. This parameter is based on the observed

shift of pilot control emphasis from pitch attitude control during power approach to flight path control during flare to touchdown. The calculation of LSP combines simple, intuitive pilot models with classical root locus and frequency response techniques. In this research, a new criterion based on LSP to predict expected pilot ratings is presented. Although developed from data for fighter-type aircraft, the LSP criterion successfully predicts pilot ratings for large transport and space shuttle configurations as well. This criterion is developed only for aircraft using front-side of the power curve landing techniques. The prediction success of this criterion compares well with the success of MIL-F-8785C Flying Qualities criteria. Recommendations include the consideration of LSP for the Flying Qualities Handbook. GRA

N87-22677# Georgia Inst. of Tech., Atlanta.
ANALYSIS OF STRUCTURES WITH ROTATING, FLEXIBLE SUBSTRUCTURES APPLIED TO ROTORCRAFT AEROELASTICITY IN GRASP (GENERAL ROTORCRAFT AEROMECHANICAL STABILITY PROGRAM)
DEWEY H. HODGES, A. STEWART HOPKINS, and DONALD L. KUNZ (Army Aviation Research and Development Command, Moffett Field, Calif.) 1987 11 p
(AD-A178941) Avail: NTIS HC A02/MF A01 CSCL 20K

The initial version of the General Rotorcraft Aeromechanical Stability Program (GRASP) was developed for analysis of rotorcraft in steady, axial flight and ground contact conditions. In these flight regimes, the material continua of the rotorcraft may experience deformations which are independent of time. GRASP can obtain this steady-state solution and can solve the eigenproblem associated with perturbations about such a steady-state solution. GRASP is the first program implementing a new method for dynamic analysis of structures, parts of which may be experiencing discrete motion relative to other parts. Application of this new method to GRASP, including substructuring, frames of reference, nodes, finite elements and constraints, is described in the paper. The library of finite elements includes a powerful nonlinear beam element that incorporates aeroelastic effects based on a simple nonlinear, aerodynamic theory with unsteady induced inflow. GRA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A87-35672
AVIONICS SYSTEMS INTEGRATION - THERE IS A BETTER WAY
MERLIN G. JOHNSON (Teledyne Systems Co., Northridge, CA) Vertiflite (ISSN 0042-4455), vol. 33, Mar.-Apr. 1987, p. 18-22.

An approach to minimizing the total cost of Special Test Equipment is presented, following the example set by the SH-60F CV/ASW Helicopter (CV Helo) mission avionics system development program. A single full-capability System Integration Facility was built in transportable form. For the CV Helo (served by a crew of four), the avionics system is integrated by a new Tactical Data Management Subsystem (TDMS) with the following elements: dual redundant MIL-STD-1553B data bus; dual redundant tactical data processors; four identical programmable control-display units; dual independent multifunction displays; dual electronic horizontal situation video displays; centralized TEMPEST-capable communication system controller; integrated armament system controller; and a dual redundant red/black bus isolator. Advantages of the approach - including savings in time and costs, ability to provide a complete closed-loop real-time simulation environment for system integration and software validation, and application to other aircraft - are noted. D.H.

A87-36282#
ON-BOARD CARGO OPERATION SYSTEM
K.-D. MARR (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 32 p.
(SAWE PAPER 1696)

Because load-and-trim (L&T) sheet calculation is a time-consuming and complicated procedure and the loading of cargo on aircraft with containers and pallets is subject to strict regulation, it is seen that the calculation process is well suited for computerization. Design aims for the On-Board Cargo Operations (OBCO) system include: lower drag and less fuel consumption because of minimized trim; optimization of the L&T sheet preparation using either an on-board conmputer or a data-link to ground computers, with an on-board printer; maximum usage of loading capacity; and higher accuracy of takeoff weight and CG location calculations. Ball mats are used that incorporate integrated weight sensors and a sensor amplifier which transmits the signal to the sensor interface unit. A sensor interface unit in each cargo conpartment digitizes the signals and transmits the information to the computer. Comparison of OBCO-optimized L&T sheets with the manual L&T sheets shows a significant increase of optimum center-of-gravity locations. The share of CG locations greater than 25 percent MAC increased to 33 percent of the flights, even though much of the cargo was of equal density, leaving little room for optimization. D.H.

A87-36304
AN OPERATIONAL LOADING ANALYSIS OF THE B-757-232 AIRCRAFT
W. STEVEN STRICKLIN (Delta Air Lines, Inc., Atlanta, GA) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 26 p.
(SAWE PAPER 1742)

An overview is given of the development of the B-757 Weight and Balance Control System, with specific considerations associated with the Air Cargo Equipment Loading System (ACE System). The aircraft is a 'new' design but does not include any type of containerized cargo system. The ACE system was included to reduce manpower requirements and to maintain necessary ground turnaround times. The ACE System is essentially a series of inter-nesting movable tray modules which suffice for a containerized system. This new form of loading automation required development of new accountability procedures for weight and CG determinations. A CG control solution was devised, using a variable moment arm based on which loading areas are utilized. A problem considered is that where the CG is found to be unexpectedly far forward due to relatively heavy first-class passenger utilization on certain flights. D.H.

A87-36770
USE OF A COMPUTER NETWORK WITH OPTICAL BUS COMMUNICATION IN THE DFVLR FLIGHT TEST SYSTEM ATTAS [EINSATZ EINES RECHNERVERBUNDSYSTEMS MIT OPTISCHER BUSKOMMUNIKATION IM DFVLR-FLUGVERSUCHSTRAEGER ATTAS]
HANS-HEINZ LANGE, DIETRICH HANKE, and WILFRIED NIETSCHKE (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 159-170. In German. refs
(DGLR PAPER 86-151)

The flight-test aircraft ATTAS, a universally applicable flight simulator and demonstrator of new civil-aviation technologies, has as its core a redundant computer network consisting of nine computers connected via a fast serial, optical data bus with a ring structure. The system architecture, the bus structure, and the computer communication system are described here. The software development methods and software validation are examined in the context of a full-scale, on-ground system simulation. C.D.

A87-36785
FUTURE USE OF KNOWLEDGE-BASED SYSTEMS FOR MAN-MACHINE INTERFACES IN AIR TRANSPORT SYSTEMS [ZUKUENFTIGER EINSATZ WISSENSBASIERTER SYSTEME FUER DIE MENSCH/MASCHINE-SCHNITTSTELLE IN SYSTEMEN DER LUFTFAHRT]
HELMUT STEIN (DFVLR, Brunswick, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 281-289. In German. refs
(DGLR PAPER 86-159)

Concepts for the use of knowledge-based systems in air and space travel are presented. The state of the art in such systems is reviewed, and the goals of research in knowledge-based systems for the man/machine interface are discussed. Examples of the use of such systems are described, including their application as autonomous assistants in cockpits and as man/machine interfaces in flight safety and in mission control and experimentation during space flights. C.D.

A87-37429#
ON-BOARD DATA ACQUISITION AND PROCESSING SYSTEM
MICHAEL DAHAN (Israel Aircraft Industries, Ltd., Flight Test Engineering Dept., Lod, Israel) IN: ITC/USA/ '86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 673-685.

This paper describes an on-board PCM data acquisition and processing system using standard PCM units and commercial microcomputer equipments. A special interface, which was developed in order to allow a direct connection to PCM encoders, is also presented. It performs data buffering and decommutation prior to the data acquisition process. This approach facilitated the independent conduction of flight tests away from the users' ground stations using a minimal investment. It helped to provide test results in flight or immediately after flights, thus shortening the flight test processing turn around time and contributing to expedite the overall flight test program. Author

N87-21902# Royal Aircraft Establishment, Bedford (England). Flight Systems Div.
SOME EXPERIENCES IN INTEGRATING AVIONIC SYSTEMS ON THE CIVIL FLIGHT DECK
P. ENGLAND, R. HARLOW, and N. COOKE *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 17 p Dec. 1986
Avail: NTIS HC A15/MF A01

Some of the work carried out in the Civil Avionics Research program at the Royal Aircraft Establishment, Bedford is described. After a discussion of some of the factors that are leading to a future Air Traffic Management system, the activities in navigation, flight management, displays and novel human input techniques are reviewed. The progress made and some of the lessons learned are also described. A view of how a future air traffic management system might operate is given. Author

N87-21918# Army Aviation Engineering Flight Activity, Edwards AFB, Calif.
EVALUATION OF THE SAFE FLIGHT INSTRUMENT CORPORATION STALL WARNING SYSTEM FOR THE OV/1D AIRCRAFT Final Report, 26 Oct. - 26 Nov. 1985
JOSEPH C. MIESS, ROBERT D. ROBBINS, and JEFFREY L. LINEHAN Feb. 1986 42 p
(AD-A177364; USAAEFA-85-16) Avail: NTIS HC A03/MF A01 CSCL 01D

An evaluation of the Safe Flight Instrument Corporation (SFIC) stall warning system for the OV-1D aircraft was conducted by the US Army Aviation Engineering Flight Activity (AEFA) to determine variation in stall warning margins from those observed in USAAEFA Project No. 84-13 resulting from changes in the SFIC stall warning system and aircraft configuration. Changes in aircraft configuration included incorporation of wing tip radar jammer antenna fairings (AN/ALQ-136(V)2), and modification of the right wing deice boot to accept the stall warning system lift transducer. Changes in the SFIC stall warning system included addition of a pendulous accelerometer and software changes to the lift computer, and replacement of the 700 Hertz (Hz) audio tone generator with a 400 Hz audio tone generator. The test aircraft was equipped with the Louvered Scarfed Shroud Suppressor (LSSS) and was flown with and without external aircraft mission/survivability equipment installed. The evaluation was conducted at Edwards Air Force Base, California between 26 October and 26 November 1985 and consisted of 23 flights totaling 40.5 flight hours (32.5 productive flight hours). The evaluation consisted of two phases during which dual and single-engine unaccelerated stalls, dual-engine accelerated stalls and evasive maneuvers were performed. GRA

N87-21919# Air War Coll., Maxwell AFB, Ala.
F-16 DIGITAL TERRAIN SYSTEM: CONCEPT OF OPERATIONS AND SUPPORT
PAULL C. BURNETT, MANUEL W. GARRIDO, RONNIE K. MORROW, and BARTON C. TUCKER Mar. 1986 70 p
(AD-A177737; AD-E751201; AU-AWC-86-215) Avail: NTIS HC A04/MF A01 CSCL 01D

Presented is a concept of operations and support for an F-16 equipped with a digital terrain system (DTS) using stored digital, three-dimensional terrain data. By overlaying the terrain data with route information threats, and cultural features, it is possible to display to the pilot all required map information. Additional DTS functions include automated mission planning, inflight retargeting, autonomous navigation, and ground proximity warning. These capabilities will reduce pilot workload by providing a single-glance tactical situation overview and allow the pilot to know exactly where he is at all times in flight to better avoid threats and make maximum use of terrain masking. In an operational environment with increasingly sophisticated threats, the DTS offers the potential to increase survivability and lethality by enhancing pilot situational awareness and reducing pilot workload. A significant part of this workload reduction will be acheived by automating mission planning on the ground to include preprogramming many of the pilot selectable features such as map scale, changes from plan view to perspective view, changes in cultural features to be shown, and sensor cueing against specific targets (sensor prepointing). Mission phases presented include mission planning; ground operations; low-level ingress and egress; air-to-surface operations both conventional and nuclear; air-to-air operations; and routine flight operations. GRA

N87-21920# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Flight Mechanics Panel.
MICROPROCESSOR APPLICATIONS IN AIRBORNE FLIGHT TEST INSTRUMENTATION
M. J. PRICKETT Feb. 1987 66 p
(AGARD-AG-160-VOL-18; ISBN-92-835-1542-0; AD-A178983)
Avail: NTIS HC A04/MF A01

This volume in the AGARD Flight Tests Instrumentation Series addresses flight test engineers and flight test instrumentation engineers interested in the design of microprocessors into new airborne flight test equipment. It describes general microprocessor based, system design principles and architectures suitable for flight test and flight test instrumentation applications. In preparing this volume the author has met with several engineers actively participating in aircraft and electronic flight testing at various organizations. Each of these organizations has developed microprocessor based instrumentation to solve their unique requirements and these are described in this text as case studies of current microprocessor applications. Author

N87-21921*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE EFFECTS OF DISPLAY AND AUTOPILOT FUNCTIONS ON PILOT WORKLOAD FOR SINGLE PILOT INSTRUMENT FLIGHT RULE (SPIFR) OPERATIONS Final Report
ROGER H. HOH, JAMES C. SMITH (Systems Technology, Inc., Hawthorne, Calif.), and DAVID A. HINTON Washington NASA 1987 107 p
(Contract NAS1-17928)
(NASA-CR-4073; NAS 1.26:4073) Avail: NTIS HC A06/MF A01 CSCL 01D

An analytical and experimental research program was conducted to develop criteria for pilot interaction with advanced controls and displays in single pilot instrument flight rules (SPIFR) operations. The analytic phase reviewed fundamental considerations for pilot workload taking into account existing data, and using that data to develop a divided attention SPIFR pilot workload model. The pilot model was utilized to interpret the two experimental phases. The first experimental phase was a flight test program that evaluated pilot workload in the presence of current and near-term displays and autopilot functions. The second experiment was conducted on a King Air simulator, investigating the effects of co-pilot functions in the presence of very high SPIFR workload. The results indicate that the simplest displays tested were marginal for SPIFR operations. A moving map display aided the most in mental orientation, but had inherent deficiencies as a stand alone replacement for an HSI. Autopilot functions were highly effective for reducing pilot workload. The simulator tests showed that extremely high workload situations can be adequately handled when co-pilot functions are provided. Author

N87-22678* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AIRCRAFT CONTROL POSITION INDICATOR Patent
DALE V. DENNIS, inventor (to NASA) (Kentron International, Inc., Hampton, Va.) 5 May 1987 9 p Filed 8 Feb. 1984Supersedes N84-20522 (22 - 11, p 1607)
(NASA-CASE-LAR-12984-1; US-PATENT-4,663-627; US-PATENT-APPL-SN-578387; US-PATENT-CLASS-340-975; US-PATENT-CLASS-73-178-R; US-PATENT-CLASS-244-1-R; US-PATENT-CLASS-340-945; US-PATENT-CLASS-340-971)
Avail: US Patent and Trademark Office CSCL 01D

An aircraft control position indicator was provided that displayed the degree of deflection of the primary flight control surfaces and the manner in which the aircraft responded. The display included a vertical elevator dot/bar graph meter display for indication whether the aircraft will pitch up or down, a horizontal aileron dot/bar graph meter display for indicating whether the aircraft will roll to the left or to the right, and a horizontal dot/bar graph meter display for indicating whether the aircraft will turn left or right. The vertical and horizontal display or displays intersect to form an up/down, left/right type display. Internal electronic display driver means received signals from transducers measuring the control surface deflections and determined the position of the meter indicators on each dot/bar graph meter display. The device allows readability at a glance, easy visual perception in sunlight or shade, near-zero lag in displaying flight control position, and is not affected by gravitational or centrifugal forces.
Official Gazette of the U.S. Patent and Trademark Office

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and onboa rd auxiliary power plants for aircraft.

A87-36698
EUROPE CONSOLIDATES ITS TURBOSHAFT FAMILY
CHARLES GILSON Interavia (ISSN 0020-5168), vol. 42, March 1987, p. 255-258.

Three major European manufacturers have singly or jointly developed a family of helicopter turboshaft engines, ranging in power from 340 kW to 2240 kW, that could reach markets by the mid-1990s. Attention is presently given to these powerplants' performance characteristics, prospective helicopter applications, commercial viability in competition with comparable engines that are known to be approaching marketing by American manufacturers, and the design features to be introduced in each of the engines in the interest of competitive advantage. O.C.

A87-36800#
IMPROVING THE AIR-COMBAT CAPABILITY OF FUTURE FIGHTER AIRCRAFT. II - THRUST VECTORING FOR COMBAT-AIRCRAFT ENGINES [STEIGERUNG DER LUFTKAMPFFAEHIGKEIT VON ZUKUENFTIGEN JAGDFLUGZEUGEN. II - SCHUBVEKTORISIERUNG BEI TRIEBWERKEN FUER KAMPFLUGZEUGE]
HELMUT A. GEIDEL (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) DGLR, Jahrestagung, Munich, West Germany, Oct. 8-10, 1986, Paper. 8 p. In German. refs

Circular- and rectangular-cross-section directable convergent/divergent afterburner-engine nozzles to improve the maneuverability of combat aircraft are described and illustrated with drawings and diagrams. Consideration is given to the overall configuration, seal design, and actuator dynamics of the circular nozzle and to the transition duct, side walls, primary and secondary flaps, heat shields, actuator system, external shrouds, seals, and cooling of the rectangular nozzle. The circular nozzle weighs about 1.3 times as much as a conventional nozzle, can be installed with only minimal modifications to the aircraft, and permits vectoring up to about 10 deg; the rectangular nozzle weighs 3.0 times as much as the conventional nozzle and is more difficult to integrate, but permits vectoring up to about 30 deg as well as full thrust reversal. T.K.

A87-37835#
DEVELOPMENT OF AIRCRAFT ENGINE COMBUSTORS
XIAOQING ZHOU (Ministry of Aviation Industry, People's Republic of China) Journal of Aerospace Power, vol. 2, Jan. 1987, p. 1-7, 87. In Chinese, with abstract in English.

The principal requirements for combustors in advanced, high-technology aircraft engines are reviewed. Key technologies are briefly described and new developmental approaches are introduced. The combustor types addressed include coaxial combustors, axially or radially staged combustors, varying geometry combustors, twin recirculation combustors, horseshoe combustor domes, vortex burning afterburners, etc. Technologies affecting spray quality and combustor-dome fuel-air mixture preparation, advanced cooling systems, and heat-resistant materials are examined. The influence of laser and computer technologies on the development of combustor technology is addressed. C.D.

A87-37840#
ENGINEERING EVALUATION OF STEADY OPERATING MARGIN OF A DUAL-ROTOR COMPRESSOR
HEFU JIANG (Li Yang Machinery Co., People's Republic of China) Journal of Aerospace Power, vol. 2, Jan. 1987, p. 45-48, 91. In Chinese, with abstract in English.

The characteristics of the steady (surge-free) operating margin of a dual-rotor compressor in a turbojet engine are discussed, and the practical technical requirements are given for engineering evaluation of the steady operating margin. For the dual-rotor compressor, there is a great influence of the ratio n2/n1 (HP rotor speed to LP rotor speed) on the steady operating margin. In order to guarantee the steady operation of the compressor in the whole flight envelope, it is necessary to check the surge-free operating margin not only in a specified range of the LP rotor speed but also in a specified range of n2/n1. A numerical example of a turbojet engine is given to illustrate the above requirements. Author

A87-37841#
MEASUREMENTS AND ANALYSIS OF SURGE, STALL AND SURGE POINT PARAMETERS IN TURBOJET COMPRESSORS
WENLAN LI, FUQUN CHEN, ZONGYUAN WANG, and MENGZI CONG (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power, vol. 2, Jan. 1987, p. 49-54, 92. In Chinese, with abstract in English. refs

The testing and measurement method for three kinds of flow instability tests are presented along with test results and analysis for a turbojet engine with 'clean' or distorted inlet flow. The results show that: (1) for either type of inlet flow the surge in the engine is a classic or deep surge; (2) with random fluctuation of total pressure in the engine face, the surge is always a 'drift' surge; (3) the value of the parameters on the surge point is correlated with the forced surge method; and (4) at n-bar = 0.87, the values of the pressure ratio and mass flow by dynamically forced surge are 2.8 percent and 1.7 percent respectively, values smaller than those obtained by statically forced surges. C.D.

A87-37844#
FLIGHT TEST RESEARCH ON STATIC CHARACTERISTICS OF AFTERBURNER FUEL CONTROL SYSTEM FOR TURBOJET ENGINES
LIYI TAO, ZHANPING CHEN (Flight Test Research Center, People's Republic of China), SIQI FAN, and CHIHUA WU (Northwestern Polytechnical University, Xian, People's Republic of China) Journal of Aerospace Power, vol. 2, Jan. 1987, p. 65-68, 93, 94. In Chinese, with abstract in English.

The operation and function of the pressure ratio controller and the air pressure controller in the afterburner fuel control unit (AFCU) are investigated based on data obtained from flight tests and laboratory experiments on four AFCU models for turbojet engines. It is found that there are three operational conditions of the afterburner fuel control system. The fuel flow rate fed to the afterburner is controlled independently by the pressure ratio controller only during ground operations or in low altitude flight at high velocities, while the air pressure controller does not function. Within the major range of the flight envelope, both the pressure ratio and the air pressure controllers function and control the fuel flow rate jointly. The air pressure controller may function and control the fuel flow rate alone only in high altitude (near ceiling) flight at low velocities. Author

A87-37845#
EXPERIMENTAL INVESTIGATION ON COOLING EFFECTIVENESS OF HIGH-TEMPERATURE AIR-COOLED TURBINE BLADE
SHISHEN WU and ZHI JUN ZHANG (Shenyang Aeroengine Research Institute, People's Republic of China) Journal of Aerospace Power, vol. 2, Jan. 1987, p. 69-71, 94. In Chinese, with abstract in English.

This paper deals with the application of static test results at low temperature and low pressure to actual engine operating conditions. In order to extrapolate the test-bed results of the cooling effectiveness of a turbine blade to actual conditions of engine operation, two methods are presented: (1) to derive the experimental relationship of cooling effectiveness by heat transfer analysis; (2) to substitute the cooling effectiveness tests at low temperature and low pressure for those at high temperature and high pressure according to the similarity principle. Five kinds of blades in the same shape but with different internal structure have been tested for cooling effectiveness at various conditions. The results show that the two methods are satisfactory. Author

A87-37846#
EXPERIMENTAL INVESTIGATION ON COOLING EFFECTIVENESS OF A TURBINE BLADE UNDER VARIOUS DESIGN CONDITIONS
ZHIJIANG XUAN and SANDUO ZHANG (Xian Aeroengine Co., People's Republic of China) Journal of Aerospace Power, vol. 2, Jan. 1987, p. 72-74, 95. In Chinese, with abstract in English.

Blade cooling characteritics under various design conditions were obtained from turbine blade cooling effectiveness experiments on a given aeroengine and its two modifications. The results obtained provide useful data for air-cooled blade design. Structure and testing approach of the blades are also described. Experimental results are also analyzed. The analysis demonstrates that the testing technique is available, the experimental data are amenable and satifactory for air-cooled blade design. Author

A87-37847#
COOLING FLOW TECHNIQUE FOR DESIGNING AFTERBURNER HEAT SHIELDS
KANGBAO LIAN (Li Yang Machinery Co., People's Republic of China) Journal of Aerospace Power, vol. 2, Jan. 1987, p. 75-77, 95. In Chinese, with abstract in English.

By employing the air flow cooling technique, an afterburner heat shield was designed semiempirically. It exhibited the desired advantages of long service life, low wall temperature, and good performance. The cooling air flow accounted for 10 percent of the total airflow. The distribution of the cooling air was designed in reference to successful designs. The practice of the aeroengine with the designed afterburner verifies that the presented technique is reliable. Author

A87-37850#
THERMAL EFFECTS ON TRANSIENT PROCESS OF A TURBOJET ENGINE
DAGUANG CHEN and YONGQUAN PAN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Journal of Aerospace Power, vol. 2, Jan. 1987, p. 85, 86, 96. In Chinese, with abstract in English.

A single-shaft turbojet engine has been tested for cold and hot transient processes. The comparative test results show that thermal effects have significant influence on the acceleration time, the changing rate of aerothermodynamic parameters with engine speed, etc. The results also demonstrate that thermal effects must be taken into account in order to establish an accurate mathematical model for the transient process of turbine engines. C.D.

A87-38034#
GE'S BIG FAN GETS BIGGER
GRAHAM WARWICK and JOHN MARSDEN Flight International (ISSN 0015-3710), vol. 131, May 23, 1987, p. 27-31, 34.

The CF6-80C2 high-bypass turbofan being offered for use by MD-11 and A330 next-generation airliners has a thrust rating in excess of 60,000 pounds, and incorporates a new fan and digital controls. A maintenance 'shop-visit' rate of only 0.02/1000 hours has been achieved. All aerodynamically active elements of the engine are of fully three-dimensional design, the 14-stage high pressure compressor employs blades that have been retwisted and recambered for maximum efficiency, and great care has been taken with stage-to-state sealing. An exploded-view drawing of the engine's design features is presented. O.C.

A87-38467#
PERFORMANCE OF A HIGH-EFFICIENCY RADIAL/AXIAL TURBINE
C. RODGERS and R. GEISER (Sundstrand Corp., San Diego, CA) ASME, Transactions, Journal of Turbomachinery (ISSN 0889-504X), vol. 109, April 1987, p. 151-154. refs
(ASME PAPER 86-GT-18)

This paper presents the test performance of a lightly loaded, combination radial/axial turbine for a 420-hp, two-shaft gas turbine. This two-stage turbine configuration, which included an interstage duct and an exhaust duct discharging vertically to ambient pressure conditions, was shown to be capable of attaining an overall isentropic efficiency of 89.7 percent. The influence of exhaust diffuser struts on the turbine performance under stalled power turbine conditions was shown to significantly affect compressor and turbine matching. Author

A87-38702#
INCREASED AVIONICS COOLING CAPACITY FOR F-15 AIRCRAFT
RICHARD DIECKMANN, OTTO KOSFELD (McDonnell Aircraft Co., Saint Louis, MO), and LARRY C. JENKINS (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 1-9.
(SAE PAPER 860910)

Avionics cooling capacity of the F-15 Environmental Control System is being increased significantly. This increase is provided by integration of a high pressure water separator (HPWS) in place of the present low pressure water separator. Avionics cooling capacity of the present ECS is limited by its cooling air flow and supply temperature capabilities. Maximum flow is determined by the nozzle area of the cooling turbine. Minimum supply temperature is established so the air contains no liquid water. This temperature depends on the water removal capability of the low pressure water separator. The new HPWS removes more water from moist air than the present system. This allows colder, dry air to be supplied for avionics cooling. With colder supply air, less flow is needed to cool the same avionics. Since the system can provide the same flow with either water separator system, more avionics can be cooled by incorporating the HPWS. Author

A87-38703#
INTEGRATED AIRCRAFT FUEL THERMAL MANAGEMENT
WILLIAM A. HUDSON and MARK L. LEVIN (Rockwell International Corp., El Segundo, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 11-25. refs
(SAE PAPER 860911)

An integrated configuration is proposed for airframe and engine fuel thermal management aboard advanced military aircraft, in order to make full use of the available fuel heat-sink (FHS) capacity. In addition to combining airframe and engine FHS systems, control of engine fuel burn to nozzle temperature limits is optimized. As a result, lower main tank fuel temperatures, less fuel boiloff, smaller environmental control systems, increased capacity at mission completion, and lower supplementary ram air cooling, are obtained. Three alternative FHS systems are parametrically compared as a function of mission profile, heat loads, fuel control temperatures, and component performance levels. O.C.

A87-38704#
A RAM AIR DRIVEN AIR CYCLE COOLING SYSTEM FOR AVIONICS PODS
RICHARD M. GRABOW, TODD W. KRETER (Ford Aerospace and Communications Corp., Newport Beach, CA), and GIL E. LIMBERG (AiResearch Manufacturing Co., Torrance, CA) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 27-34.
(SAE PAPER 860912)

An avionics cooling system is described which uses direct ram air cooling at low aircraft speeds and ram air driven air cycle cooling at high aircraft speeds. The air cycle cooler operates on a reverse bootstrap cycle which has numerous advantages over closed cycle refrigeration systems. It requires no electrical power during flight since all of the power is supplied by captured ram air. A small amount of electrical power is required for ground cooling. The paper includes a description of the cooling system, the component hardware, analytical predictions and experimental measurements of air cycle cooling performance. Data are provided for internal pressures, flow rates, turbine discharge temperatures and cooling capacity. The results indicate that the system cooling capacity varies from 500 W to 1600 W at sea level and from 300 W to 400 W at an altitude of 50,000 ft. The effects of flow leakage and system pressure drop are found to be acceptable for avionics pod applications. Author

A87-38705#
X-29 FUEL/AUXILIARY OIL SYSTEMS THERMAL MANAGEMENT
STEPHEN J. BLACK (Grumman Aerospace Corp., Bethpage, NY) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conferfence on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrandale, PA, Society of Automotive Engineers, Inc., 1986, p. 35-40.
(SAE PAPER 860913)

The X-29 Fuel/Auxiliary Oil Thermal Management System provides total aircraft accessory oil cooling, including both flight and combined hydraulics, integrated drive generator oil, and accessory drive gearbox oil, with onboard fuel. Fuel cooling rates that are independent of engine demand are achieved through the use of a recirculation loop. Fuel cooling results in lower, more uniform subsystem oil temperatures, less ram drag, and smaller, lighter-weight heat exchangers. Initial design studies and laboratory development testing will be discussed. Author

A87-38807#
INVERSE DESIGN OF COOLANT FLOW PASSAGES IN CERAMICALLY COATED SCRAM JET COMBUSTOR STRUTS
T. L. CHIANG, L. J. HAYES (Texas, University, Austin), and G. S. DULIKRAVICH (Pennsylvania State University, University Park) IN: Numerical methods in heat transfer; Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 1-6. refs

The direct boundary-element method and nonlinear-constrained-minimization techniques are combined to design multiple-hole internally cooled homogeneous and composite (ceramic-coated) struts for scramjet combustors. Using this inverse-design procedure, prescribed outer-surface and coolant-passage temperature distributions and wall-thickness and hole-spacing constraints are maintained as the optimal heat-flux distribution on the outer surface is approached iteratively. Provision is made for noncircular passage cross sections, multiple struts, and unsteady heating or cooling. The mathematical model and numerical implementation are described, and results for three test cases are presented in tables, drawings, and graphs. T.K.

A87-38954#
COMPUTATIONAL MODELS FOR GAS-TURBINE COMBUSTORS
W. SHYY, S. M. CORREA, and M. E. BRAATEN (General Electric Co., Schenectady, NY) IN: Calculations of turbulent reactive flows; Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 141-183. refs

Computationally tractable models for turbulent combusting flow in complex geometries are presented and assessed. These consist of either chemically equilibrated or partially equilibrated radical pool models of varying complexity for H2 and CO/H2 fuels and laminar flamelet models. Some results in nonpremixed jet flames are reviewed showing the importance of nonequilibrium phenomena. The problems of turbulence closure models pertinent to turbulent reacting flows are also briefly discussed. Issues governing the choice of grid system, discretization operators, and numerical solution procedures for recirculating flows are also discussed. Numerical results are given to illuminate the salient points associated with these issues. A methodology for numerical simulation of flow in complex geometries is developed and applied to a modern annular gas-turbine combustor. Author

A87-38955#
CALCULATION OF AEROSPACE PROPULSION COMBUSTORS - A VIEW FROM INDUSTRY
G. J. STURGESS (United Technologies Corp., Engineering Div., East Hartford, CT) IN: Calculations of turbulent reactive flows; Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 185-231. refs

A comprehensive overall description is presented of the current problems associated with making computer-based numerical simulations of the flows in combustors for aeropropulsion systems. The emphasis is on the gas turbine engine, and the viewpoint is that from industry. The state of the art is outlined, and examples of use and performance are given. Future requirements for codes and possible developments are discussed. Author

A87-38959#
IMPACT OF NUMERICAL METHODS ON GAS TURBINE COMBUSTOR DESIGN AND DEVELOPMENT
C. H. PRIDDIN and J. COUPLAND (Rolls-Royce, Inc., Derby, England) IN: Calculations of turbulent reactive flows; Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 335-348. refs

The task of the combustion engineer is reviewed in the light of available numerical methods, and it is demonstrated how these numerical methods have influenced this task. Examples are shown of application to combustor pattern factor improvement, to diffuser flow and loss optimization, and to cooling device design improvement. The power of the coupled mesh technique and the flexibility of a boundary fitted orthogonal system are demonstrated to be essential features in the success obtained in applying a single code to all these combustor problems. Author

N87-21922# Naval Postgraduate School, Monterey, Calif.
THE EFFECTS OF METALLIZED FUEL COMPOSITION ON THE COMBUSTION CHARACTERISTICS OF SOLID FUEL RAMJETS (SFRJ) M.S. Thesis
ADONIS KARADIMITRIS Dec. 1986 79 p
(AD-A176744) Avail: NTIS HC A05/MF A01 CSCL 21B

Experiments investigated the effects of metallized fuel composition on the combustion characteristics of solid fuel ramjets (SFRJ). Metallized fuels were burned in a two dimensional SFRJ motor under conditions similar to actual flight conditions proposed for solid fuel ramjets. Pressure, air inlet temperature and flowrate measurements were taken using an automatic data acquisition system. High speed motion pictures were taken of the interior or the combustor during the burning of the solid fuel through two viewing windows located in the recirculation zone and just prior to the aft mixing chamber where the boundary layer was more fully developed. Tests were conducted at mass fluxes of 0.2 and 0.5 lbm sq in. sec, with pressures ranging from 57 to 200 psia and with a nominal inlet air temperature of 1100 R. Most fuel surfaces had a characteristic shedding of small, unignited flakes. The flakes are thought to be binder material, and were more prevalent at lower pressures. Occasional shedding of large surface layers was observed, especially during motor shutdown. Metallic surface agglomerations appeared to interact strongly with these irregular surface layers. Large magnesium particles exhibited the expected bright ignition characteristics. Boron particles were not observed, apparently because they were smaller than the resolution limits of the motion pictures. GRA

N87-21924# Sverdrup Technology, Inc., Arnold Air Force Station, Tenn.
A POST-STALL COMPRESSION SYSTEM MODELING TECHNIQUE Final Report, 1 Oct. 1984 - 30 Sep. 1986
M. W. DAVIS, JR. Feb. 1987 98 p Prepared in cooperation with AEDC, Arnold Air Force Station, Tenn.
(AD-A177610; AEDC-TR-86-34) Avail: NTIS HC A05/MF A01 CSCL 21E

This report presents a one dimensional, stage by stage compression system modeling technique capable of exhibiting post stall behavior such as surge and rotating stall. Included is a brief overview of previous efforts by others, their major contributions and how the present effort enhances and extends these efforts. THe modeling techniques, governing equations, numerical simulation, and stability criteria are all discussed. The model is validated by comparing it with a multitude of experimental test results from low-speed and high-speed compressor rigs and engine test results. The model provides an analysis tool for analyzing compression system and individual stage behavior during surge and rotating stall. Because the modeling technique is based upon stage characteristics, stage modifications can be analyzed for their affect on recoverability. GRA

N87-21926 California Univ., Los Angeles.
STRUCTURAL DYNAMIC MODELING OF ADVANCED COMPOSITE PROPELLERS BY THE FINITE ELEMENT METHOD Ph.D. Thesis
JOHN BENEDICT KOSMATKA 1986 332 p
Avail: Univ. Microfilms Order No. DA8702598

An analytical model is presented for determining the free vibration characteristics of conventional and advanced propellers composed of generally anisotropic materials (i.e., composite construction). It is assumed that the propeller is discretized into a series of straight beams (beam-type finite element), where the elastic axis of each beam element is aligned with the line of shear centers of the propeller. Blades of arbitrary shape and definition can be analyzed, since this line of shear centers is represented by a general space curve. Results include: (1) verification studies that were done with known analytical and experimental solutions, and (2) the determination of the structural dynamic characteristics of a conventional propeller and an advanced propeller. Results from these studies show very good agreement with experimental data. A model, which is used to determine the shear center, structural constants, and shear stress distribution of an arbitrary shaped cross section composed of multiple generally anisotropic materials is also presented. Dissert. Abstr.

N87-21927# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Propulsion and Energetics Specialists.
TRANSONIC AND SUPERSONIC PHENOMENA IN TURBOMACHINES
Loughton, England Mar. 1987 374 p In ENGLISH and FRENCH Meeting held in Munich, West Germany, 10-12 Sep. 1986
(AGARD-CP-401; ISBN-92-835-0413-5) Avail: NTIS HC A16/MF A01

The Specialists' Meeting was arranged in the following sessions: Experimental Data on Shock Structures; Shock Induced Losses

Including Shock Boundary Layer Interaction; Computational Results; and Blade Design Methods. In order to maintain high efficiency and reliability of advanced engines with high speed in compressors and turbines, a deep understanding of the influence of transonic and supersonic phenomena is essential. The meeting was aimed at providing a contribution to this goal.

N87-21929*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SHOCK STRUCTURE MEASURED IN A TRANSONIC FAN USING LASER ANEMOMETRY
JERRY R. WOOD, ANTHONY J. STRAZISAR, and P. SUSAN SIMONYI (Sverdrup Technology, Inc., Middleburg Heights, Ohio.) *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 14 p Mar. 1987
Avail: NTIS HC A16/MF A01 CSCL 21E

Shock structure measurements acquired in a low aspect ratio transonic fan rotor are presented and analyzed. The rotor aspect ratio is 1.56 and the design tip relative Mach number is 1.38. The rotor flowfield was surveyed at near maximum efficiency and near stall operating conditions. Intra-blade velocity measurements acquired with a laser fringe anemometer on blade-to-blade planes in the supersonic region from 10 to 60% span are presented. The three-dimensional shock surface determined from the velocity measurments is used to determine the shock surface normal Mach number in order to properly calculate the ideal shock jump conditions. The ideal jump conditions are calculated based upon the Mach numbers measured on a surface of revolution and based upon the normal Mach number to indicate the importance of accounting for shock three dimensionality in turbomachinery design. Comparison of the shock locations with those predicted by a 3-D Euler code showed very good agreement and indicated the usefulness of integrating computational and experimental work to enhance the understanding of the flow physics occurring in transonic turbomachinery passages. Author

N87-21930# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Dept. of Engineering Sciences.
WAKE AND SHOCK INTERACTIONS IN A TRANSONIC TURBINE STAGE
D. L. SCHULTZ, A. B. JOHNSON, D. A. ASHWORTH, M. J. RIGBY, and J. E. LAGRAFF (Syracuse Univ., N. Y.) *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 16 p Mar. 1987
Avail: NTIS HC A16/MF A01

The strong trailing-edge shock waves from the nozzle guide vanes of transonic turbine stages can give rise to interactions with the downstream rotor which are significantly more severe than is the case with lower pressure ratio stages. It is therefore important to study such effects in detail both from the point of view of stage power output and more importantly from that of heat transfer rates. Transonic rotor profile was made in a static cascade in which the effect of shock wave interaction is simulated by means of an array of bars rotating at the correct speed and spacing upstream of the stationary rotor blades. Detailed heat transfer rate measurements made with rapid response gauges enable the wake and shock phenomena to be separated. Author

N87-21931# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Inst. fuer Entwurfsaerodynamik.
THE BOUNDARY LAYER BEHAVIOUR OF HIGHLY LOADED COMPRESSOR CASCADE AT TRANSONIC FLOW CONDITIONS
H. HOHEISEL and N. J. SEYB (Rolls-Royce Ltd., Bristol, England.) *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 17 p Mar. 1987
Avail: NTIS HC A16/MF A01

The design of efficient blade profiles for gas turbine compressors can no longer be effectively carried out through the use of correlations of 2D-cascade data. For the description of the real flow field three dimensional effects have to be taken into account. Modern theoretical calculation methods which involve the determination of blade profile pressure distribution and the associated boundary layer parameters, are now becoming accepted practice. However before the engine designer can have confidence in these methods the predicted performance must be demonstrated to be in good agreement with experimental data. An accurate set of experimental measurements of blade profile pressure distributions and boundary layer parameters are presented under quasi-3D-flow conditions and these are compared with the predicted performance for a high deflection transonic compressor cascade. It is shown that for conditions near minimum loss incidence the agreement between measure and predicted values is achieved to an adequate engineering standard and that the two most important aspects, choking flow and boundary layer separation are well predicted. Also the data presented could be used to further update and improve the current prediction methods. Author

N87-21932*# Massachusetts Inst. of Tech., Cambridge. Gas Turbine Lab.
VORTEX SHEDDING IN COMPRESSOR BLADE WAKES
A. H. EPSTEIN, J. B. GERTZ, P. R. OWEN, and M. B. GILES *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 13 p Mar. 1987 Sponsored by NASA. Lewis Research Center and AFOSR
Avail: NTIS HC A16/MF A01 CSCL 21E

The wakes of highly loaded axial compressor blades were often considered to be turbulent, unstructured flows. Recent work has suggested that the blade wakes are in fact dominated by a vortex street-like structure. The work on the wake structure at MIT is reviewed, the results of a viscous numerical simulation are presented, the blade wake vortices are compared to those shed from a cylinder, and the implications of the wake structure on compressor performance are discussed. In particular, a two-dimensional, time accurate, viscous calculation shows both a periodic wake structure and time variations in the passage shock strength. The numerical calculations are compared to laser anemometer and high frequency response probe data. The effect of the wake structure on the entropy production and apparent adiabatic efficiency of the compressor rotor is discussed. Author

N87-21934# Cambridge Univ. (England). Whittle Lab.
MEASURED AND PREDICTED LOSS GENERATION IN TRANSONIC TURBINE BLADING
W. N. DAWES, J.-J. CAMUS, L. P. XU, and C. G. GRAHAM (Rolls-Royce Ltd., Bristol, England) *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 11 p Mar. 1987
Avail: NTIS HC A16/MF A01

For a typical transonic turbine rotor blade, designed for use with coolant ejection, the trailing edge, or base loss is three to four times the profile boundary layer loss. The base region of such a profile is dominated by viscous effects and its seems essential to attack the problem of loss prediction by solving the compressible Navier-Stokes equations. However, such an approach is inevitably compromised by both numerical accuracy and turbulence modeling constraints. A Navier-Stokes solver written for 2D blade-blade flows and employing a simple two-layer mixing length eddy viscosity model are described. Then, measured and predicted losses and base pressures are presented for two transonic rotor blades and attempts are made to assess the capabilities of the Navier-Stokes solver and to outline areas for future work. Author

N87-21935# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
INFLUENCE OF SHOCK AND BOUNDARY-LAYER LOSSES ON THE PERFORMANCE OF HIGHLY LOADED SUPERSONIC AXIAL FLOW COMPRESSORS
K. D. BROICHHAUSEN and H. E. GALLUS (Technische Hochschule, Aachen, West Germany) *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 14 p Mar. 1987
Avail: NTIS HC A16/MF A01

Performance and losses of trans/supersonic axial flow compressors are influenced by shock structure, shock-boundary layer interactions and boundary layer separation. The combination

of these phenomena and their effects on the flow characteristics of supersonic compressors are discussed. For this purpose experimental results are compared with theoretical approaches involving different semi-empirical correlations for shock and boundary layer losses, for separation and flow deviation. By an appropriate combination of these models the flow characteristics of supersonic compressors are interpreted and the performance of such compressors is successfully reproduced in a wide range. Finally, generally valuable statements on the design of highly loaded supersonic compressors are derived and possible perspectives are described. Author

N87-21936# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
SHOCK WAVES LOSSES ANALYSIS
ANTOINE FOURMAUX and ALAIN LEMEUR *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 11 p Mar. 1987
In FRENCH; ENGLISH summary
Avail: NTIS HC A16/MF A01

In advanced technology turbomachinery design, reducing aerodynamic losses is an important matter. Schematically, these losses have 3 origins: losses related to the leading-edge shock; losses related to the main-compression shock; and friction losses, related to the boundary layer evolution. For given inlet and outlet conditions, a judicious designing of the blade profiles may induce a minimum loss level. In order to successfully conclude such a design, some rather experimental work was recently performed in ONERA, the main results of which are presented. Leading edge shock (the influence of the leading edge shape on the shock and on its impingement on the lower blade section surface); experimental analysis of a single blade-to-blade passage in order to validate certain principles concerning shock/boundary layer interaction; and experimental analysis of a cascade in which the blade profile is specially designed to minimize the losses are examined. All projects were done on two-dimensional flow. The alternate use of theoretical and experimental methods will be emphasized. Author

N87-21937# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. fuer Antriebstechnik.
EXPERIMENTAL INVESTIGATIONS ON SHOCK LOSSES OF TRANSONIC AND SUPERSONIC COMPRESSOR CASCADES
H. A. SCHREIBER *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 15 p Mar. 1987
Avail: NTIS HC A16/MF A01

The losses of transonic and supersonic compressor bladings are due to viscous effects and due to entropy rises in shock waves arising in the entrance regions and passages of the blades. Depending on inlet Mach number, inlet flow angle, and back pressure the shock loss level reaches 40 to 70% of the overall losses. Most of the loss prediction models in use consider viscous and shock losses separately. However, very few quantitative experimental data of shock losses are available to verify these models. A separation of the viscous and shock losses is performed by the analysis of wake measurements behind some compressor cascades. The cascade tests were performed in the inlet Mach number range from 0.8 to 1.7. Detailed information is presented about the shock structure and the region of shock boundary layer interaction in the blade passage of a supersonic cascade obtained with the aid of laser anemometry. Author

N87-21940# Societe Nationale d'Etudes et de Construction de Moteurs d'Aviation, Moissy-Cramayel (France).
THREE-DIMENSIONAL COMPUTATION AROUND TURBOMACHINE BLADES WITH FINS [CALCUL TRIDIMENSIONNEL DANS LES AUBABES DE TURBO-MACHINES AVEC NOGEOIRE]
T. DERRIEN *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 15 p Mar. 1987 In FRENCH
Avail: NTIS HC A16/MF A01

The numerical solution of the Euler equations governing the flow at finned blades of a rotating wheel is presented. An explicit domain method, selected for its simplicity, is used. The analysis of the computation results, comparing blades in the same conditions with and without fins, allowed the principle influences of the fins on the aerodynamic field to be revealed. M.G.

N87-21941# Stuttgart Univ. (West Germany). Inst. fuer Luftfahrtantriebe.
A QUASI THREE DIMENSIONAL METHOD FOR THE CALCULATION OF TRANSONIC FLOWS IN TURBOMACHINES
JOERG HALLER *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 12 p Mar. 1987
Avail: NTIS HC A16/MF A01

A procedure based on the iterative coupling of flow calculations on S1 blade-to-blade stream surfaces and a flow calculation on an S2 hub-to-tip stream surface is described. The solutions on S1 surfaces of revolution are obtained by a time marching method in finite volume form, whereas a finite difference method is used for the S2 calculation. The finite difference method uses a stream function formulation based on a passage averaging technique in order to account for non-axisymmetric flows, especially with shocks inside a blade row. Sample calculations of a single-stage and a two-stage compressor are presented and compared with measurements. Author

N87-21942# Politecnico di Milano (Italy). Dipt. di Energetica.
TRANSONIC THREE-DIMENSIONAL INVISCID CALCULATIONS IN TURBOMACHINES
F. BASSI and M. SAVINI (National Center for Energetics and Propulsion, Peschiera Borromeo, Italy) *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 10 p Mar. 1987
Avail: NTIS HC A16/MF A01

A finite volume Euler solver which was applied to the calculation of the three-dimensional transonic flow field through straight cascades is described. The numerical algorithm, based on Jameson's approach, uses a centered space discretization, with explicit adaptive dissipation terms, and a three-stage Runge-Kutta method for the time integration; the convergence to the steady state solution may be enhanced by using local time step, residual smoothing, and enthalpy damping. The calculations were performed in a O-type grid, obtained by means of a constructive approach which guarantees good properties of smoothness, orthogonality, and resolution near the body. The computational code was applied to two turbine blade cascades in transonic regime tested at the von Karman Institute. Three-dimensional effects were introduced by imposing an inlet velocity profile normal to the endwall. The computational results show good agreement with the blades pressure experimental data and the code performed well in the prediction and development of the secondary flow vortices. Author

N87-21943# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
COMPUTATION OF TRANSONIC 2D CASCADE FLOW AND COMPARISON WITH EXPERIMENTS
H.-W. HAPPEL, H. J. DIETRICHS, and K. LEHMANN *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 19 p Mar. 1987
Avail: NTIS HC A16/MF A01

A time-marching finite area method to obtain the steady 2D blade-to-blade solution along an axisymmetric stream surface with changing radius and stream tube thickness is described. The conservation laws are solved in a rotating frame. The numerical scheme is explicit and first order accurate in time and space. To achieve stability, explicit numerical viscosity is added. Three alternative methods of ensuring the zero normal velocity condition along the solid walls are analyzed and their application is discussed. In order to increase the convergence speed, a sequential grid-refining procedure and a multiple-grid algorithm are used in the code. The accuracy and computational efficiency of the computer code are demonstrated for agreement for turbine and compressor cascades. Author

N87-21944# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
A NUMERICAL STUDY OF UNSTEADY FLOW EFFECTS IN A SUPERSONIC COMPRESSOR CASCADE
SCOTT M. RICHARDSON *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 11 p Mar. 1987
Avail: NTIS HC A16/MF A01

Recent experimental evidence exists which suggests that compressor cascades operating supersonically may pass a higher mass flow with a periodic inflow condition than with the thermodynamically equivalent mass-averaged steady condition. Since most compressor design methods rely on the use of an axisymmetric analysis, any excursion in mass flow caused by blade row interactions will not be accounted for in the design. The two-dimensional Navier-Stokes equations are solved using the MacCormick explicit algorithm to obtain the flow in a subsonic rotor cascade for both periodic and steady flow inlet conditions. A outflow boundary condition is presented to model the unsteady cascade exit flow conditions by using localized heat addition to produce a choke point near the downstream boundary. A computational study of the wake model parameters used in the periodic inlet boundary condition is performed to determine their effect on the cascade mass flow swallowing capacity. Author

N87-21945# Cambridge Univ. (England). Whittle Lab.
A NUMERICAL STUDY OF THE 3D FLOWFIELD IN A TRANSONIC COMPRESSOR ROTOR WITH A MODELLING OF THE TIP CLEARANCE FLOW
W. N. DAWES *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 12 p Mar. 1987
Avail: NTIS HC A16/MF A01

Modeling the complex flowfield in a transonic axial compressor rotor is a considerable but worthwhile challenge for flow prediction methods. A computer code aimed at solving the equations of three dimensional viscous compressible flow in turbomachine geometries is described. The code is applied to the study of the flowfield in a transonic axial compressor rotor at design speed for both maximum flow and towards stall. The rotor was designed and tested using laser two-focus velocimetry. The rotor has a hub-tip ratio of 0.5 and design speed of 20,260 rpm. At the design point the rotor pressure ratio is 1.626 and the mass flow 17.1 kg/s. The predicted flowfield is compared with the laser measurements and the performance of the code discussed. In addition the discussion highlights the changes in the predicted endwall and tip clearance flows as the rotor operating point is moved towards stall. Author

N87-21947# Rolls-Royce Ltd., Bristol (England). Theoretical Science Group.
SOME TURBOMACHINERY BLADE PASSAGE ANALYSIS METHODS: RETROSPECT AND PROSPECT
D. CARRAHAR and T. R. KINGSTON *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 16 p Mar. 1987
Avail: NTIS HC A16/MF A01

The development of time marching methods to analyze blades started at Rolls-Royce in the mid seventies, when sufficient computing power was becoming available. It was recognized that such methods had much to offer, especially for transonic and supersonic flows. Since then several different algorithms were developed to predict both quasi-3D and 3D flows. At present the time-marching methods are used to solve the unsteady Euler/Navier-Stokes equations to produce a time steady solution. Future developments are aimed towards predicting loss accurately, and to investigated unsteady effects such as vortex shedding and incoming wakes. Author

N87-21949# Technische Hochschule, Hanover (West Germany). Inst. fuer Stroemungsmaschinen.
DOWNSTREAM FLOW ANGLE CORRELATIONS FOR TURBINE CASCADES IN SUBSONIC AND TRANSONIC FLOW CONDITIONS
W. RIESS, P. DALBERT, P.-A. GIESS, and H.-J. HEINEMANN (Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen, West Germany) *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 20 p Mar. 1987
Avail: NTIS HC A16/MF A01

Extensive experimental and theoretical investigations of different turbine cascades were performed within the transonic Mach number range. Some problems related to measurements in rectilinear cascades are discussed. The flow field calculations performed using a time-marching Euler code limitations can be determined when applying the computer code itself as well as when comparing the calculated data with experimental ones. Experimental and theoretical results within the subsonic Mach number range are used to check the accuracy of simplified methods for calculating the downstream flow angle. Author

N87-21950# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany). Inst. fuer Antriebstechnik.
A SHOCK LOSS MODEL FOR SUPERCRITICAL SUBSONIC FLOWS IN TRANSONIC AXIAL FLOW COMPRESSORS
R. J. DUNKER *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 15 p Mar. 1987
Avail: NTIS HC A16/MF A01

This investigation was aimed at developing more sophisticated models to be incorporated in an off-design performance prediction method for transonic axial flow compressor stages for more accurate flow prediction. Primary emphasis was given to the improvement of shock models used for evaluating the shock losses, especially, at supercritical subsonic, but also at supersonic inflow conditions. The developed and refined methods were verified by calculating, investigating, and analyzing the losses of compressor cascades, as well as a transonic axial flow compressor. Author

N87-21951# KHD Luftfahrttechnik G.m.b.H., Oberursel (West Germany).
COMPARISON BETWEEN INVERSE DESIGNED (PVD) AIRFOILS AND STANDARD SERIES AIRFOILS FOR HIGH LOADED AXIAL TURBINE NOZZLE APPLICATION
M. HORSMANN and M. SCHMIDT *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 6 p Mar. 1987
Avail: NTIS HC A16/MF A01

Guide vane profiles with transonic flow regions in the flow field were developed for a high loaded one stage axial turbine. The profiles were designed in two different ways: first, using standard design techniques and second, using an inverse design method, where the profile shape is computed from prescribed velocity distributions (PVD). The results of both design methods will be presented. Comparison is made by using another computer program system to calculate the velocity distributions in the flow field, the boundary layer parameters, and the profile losses. The computed results of the first application of an inverse design method on axial turbine guide vanes show that improvements can be made. Author

N87-21952# National Aeronautical Lab., Bangalore (India). Propulsion Div.
DESIGN OF AN AXIAL FLOW RESEARCH COMPRESSOR OPERATING IN THE SUBSONIC AND TRANSONIC RANGES
K. MOHAN Nov. 1986 25 p
(NAL-TM-PR-8607) Avail: NTIS HC A02/MF A01

A high speed axial flow research compressor, indigenously designed and fabricated, has been installed and commissioned. This fully operational compressor is meant for undertaking investigations on models of axial flow compressor stages in the subsonic, transonic and supersonic flow ranges. The compressor rotor is 450 mm in diameter and the maximum possible operating speed is 18,000 r.p.m. Investigations on compressor stages of

widely varying geometric configurations can be undertaken with provision to vary different aerodynamic flow parameters, as and when required. Thus, most of the aerothermodynamic investigations related to the advanced technology compressors required for modern aircraft engines and industrial gas turbine power plants can be undertaken in this versatile research compressor. The performance capabilities and operational characteristics of this research compressor, which has been satisfactorily running since its commissioning, are presented. Author

N87-21953# National Aerospace Lab., Tokyo (Japan).
AN EXPERIMENT ON A CYLINDRICAL SCRAMJET COMBUSTOR. 1: SIMULATED FLIGHT MACH NUMBER OF 4.4
TOMOYUKI KOMURO, ATSUO MURAKAMI, KENJI KUDOU, GORO MASUYA, and NOBUO CHINZEI 1986 17 p In JAPANESE; ENGLISH summary
(NAL-TR-918; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

An experimental study was made on a cylindrical scramjet combustor with a step using vitiated air. The stagnation temperature and the pressure of the vitiated air were 1000 K and 1.5 MPa, respectively. Simulated flight speed was Mach 4.4 at a simulated altitude of 20 km. Perpendicular injection showed better mixing performance than did parallel injection. As equivalence increased, supersonic combustion was switched to subsonic combustion. Mixing in the supersonic combustion mode was very slow compared with that in subsonic mode. Author

N87-21955*# Hamilton Standard, Windsor Locks, Conn.
UNSTALLED FLUTTER STABILITY PREDICTIONS AND COMPARISONS TO TEST DATA FOR A COMPOSITE PROP-FAN MODEL Final Report
J. E. TURNBERG 15 Oct. 1986 50 p
(Contract NAS3-24088)
(NASA-CR-179512; NAS 1.26:179512; HSER-11056) Avail: NTIS HC A03/MF A01 CSCL 21E

The aeroelastic stability analyses for three graphite/epoxy composite Prop-Fan designs and post-test stability analysis for one of the designs, the SR-3C-X2 are presented. It was shown that Prop-Fan stability can be effectively analyzed using the F203 modal aeroelastic stability analysis developed at Hamilton Standard and that first mode torsion-bending coupling has a direct effect on blade stability. Positive first mode torsion-bending coupling is a destabilizing factor and the minimization of this parameter will increase Prop-Fan stability. It was also shown that Prop-Fan stability analysis using F203 is sensitive to the blade modal data used as input. Calculated blade modal properties varied significantly with the structural analysis used, and these variations are reflected in the F203 calculations. Author

N87-21956*# Hamilton Standard, Windsor Locks, Conn.
DYNAMIC RESPONSE AND STABILITY OF A COMPOSITE PROP-FAN MODEL Final Report
A. F. SMITH and B. M. BROOKS Oct. 1986 92 p
(Contract NAS3-24088)
(NASA-CR-179528; NAS 1.26:179528; HSER-11057) Avail: NTIS HC A05/MF A01 CSCL 21E

Results are presented for blade response and stability during wind tunnel tests of a 62.2 cm diameter model of a prop-fan, advanced turboprop, with swept graphite/epoxy composite blades. Measurements of dynamic response were made with the rotor mounted on an isolated nacelle, with varying tilt for nonuniform inflow, at flow speeds from 0.36 to 0.9 Mach number. The blade displayed no instabilities over the operating range tested, up to 0.9 Mach number and 10,000 RPM. Measurements are compared with those for other prop-fan models of both solid metal and graphite composite construction. The swept composite blade had less response than an unswept composite blade. Composite blades had more response than metal blades. Measurements are compared with theoretically based predictions. The 1-P blade response was significantly overpredicted using unimproved methods and somewhat overpredicted using improved methods. Unexpectedly high 2-P strain levels were measured and suggest the presence of nonlinear effects on blade response. Author

N87-22670# Rolls-Royce Ltd., Bristol (England).
PROPULSION SYSTEM TECHNOLOGIES FOR THRUST VECTORING
P. ROUND and R. F. TAPE (Rolls-Royce, Inc., Atlanta, Ga.) *In* AGARD Improvement of Combat Performance for Existing and Future Aircraft 12 p Dec. 1986
Avail: NTIS HC A07/MF A01

The Harrier/AV-8 aircraft, with its Rolls-Royce Pegasus engine, was developed primarily for vertical or short takeoff and landing operations. To achieve this it employs nozzles capable of vectoring through more than 90 deg to provide lift and a reaction control system to provide aircraft control in low or zero forward speed operation. These features of the aircraft have also been employed to advantage during combat by vectoring in forward flight (VIFFING). Operational analysis studies have identified the potential combat advantage of post-stall maneuvering (PMS) to improve rate of turn and vehicle/weapon pointing. To achieve any or all of these capabilities will require some degree of propulsion system thrust vectoring. Some particular requirements that the need for thrust vectoring place on the engine design and the technologies involved are addressed. Author

N87-22679# Naval Postgraduate School, Monterey, Calif.
GAS TURBINE COMBUSTOR AND ENGINE AUGMENTOR TUBE SOOTING CHARACTERISTICS Final Report, Oct. 1985 - Sep. 1986
J. S. BENNETT, C. H. JWAY, D. J. URICH, and D. W. NETZER Dec. 1986 85 p
(AD-A179423; NPS67-86-004) Avail: NTIS HC A05/MF A01 CSCL 21B

An experimental investigation was conducted to investigate the effects of smoke-suppressant fuel additives, fuel composition and combustor operating environment on the soot characteristics within the combustor and across an engine exhaust augmentor tube. A T63 combustor was used with fuel additive pumps and an exhaust augmentor tube. Soot mean diameters and concentrations were measured at two locations within the combustor and at the exhaust of the augmentor tube using three-wavelength light transmission and multiple-angle forward scattering measurements and collection probes. Fuel and air flow rates were varied and combustor inlet air temperature was varied using a hydrogen-fueled vitiated air heater. Combustor flow conditions were found to significantly change soot characteristics as well as the effects of smoke-suppressant fuel additives. D32(volume-to-surface mean diameter) varied between 0.10 and 0.30 microns within the combustor. D32 increased significantly across the engine augmentor tube, to sizes as large as 0.43 microns. GRA

N87-22680*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ANALYSIS OF AN ADVANCED TECHNOLOGY SUBSONIC TURBOFAN INCORPORATING REVOLUTIONARY MATERIALS
GERALD KNIP, JR. May 1987 25 p
(NASA-TM-89868; E-3542; NAS 1.15:89868) Avail: NTIS HC A02/MF A01 CSCL 21E

Successful implementation of revolutionary composite materials in an advanced turbofan offers the possibility of further improvements in engine performance and thrust-to-weight ratio relative to current metallic materials. The present analysis determines the approximate engine cycle and configuration for an early 21st century subsonic turbofan incorporating all composite materials. The advanced engine is evaluated relative to a current technology baseline engine in terms of its potential fuel savings for an intercontinental quadjet having a design range of 5500 nmi and a payload of 500 passengers. The resultant near optimum, uncooled, two-spool, advanced engine has an overall pressure ratio of 87, a bypass ratio of 18, a geared fan, and a turbine rotor inlet temperature of 3085 R. Improvements result in a 33-percent fuel saving for the specified misssion. Various advanced composite materials are used throughout the engine. For example, advanced polymer composite materials are used for the fan and the low pressure compressor (LPC). Author

N87-22681*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
SUPERSONIC THROUGH-FLOW FAN DESIGN
JAMES F. SCHMIDT, ROYCE D. MOORE, JERRY R. WOOD, and RONALD J. STEINKE 1987 21 p Prepared for presentation at the 23rd Joint Propulsion Conference, San Diego, Calif., 29 Jun. - 2 Jul. 1987; sponsored in part by AIAA, SAE, ASME and ASEE
(NASA-TM-88908; E-3492; NAS 1.15:88908; AIAA-87-1746)
Avail: NTIS HC A02/MF A01 CSCL 21E

The NASA Lewis Research Center has embarked on a program to experimentally prove the concept of a supersonic through-flow fan which is to maintain supersonic velocities throughout the compression system with only weak shock-wave flow losses. The detailed design of a supersonic through-flow fan and estimated off-design performance with the use of advanced computational codes are described. A multistage compressor facility is being modified for the newly designed supersonic through-flow fan and the major aspects of this modification are briefly described. Author

N87-22682# Aeronautical Research Labs., Melbourne (Australia).
PRELIMINARY INVESTIGATION OF THE USE OF HOLOGRAPHIC INTERFEROMETRY TO DETECT ILL-FITTING COMPRESSOR BLADES
S. J. RUMBLE and B. LAWRIE Nov. 1986 23 p
(AD-A178519; ARL/STRUC-TM-451) Avail: NTIS HC A02/MF A01 CSCL 14B

The technique of double exposure holographic interferometry has been used to detect and investigate ill-fitting compressor blades. A brief introduction to holographic interferometry is given. Holographic interferometry has enabled the observation of the displacements of blades when the blades are subjected to a small force. The potential of a pulsed laser holographic system to be used for in-situ investigations is discussed. GRA

N87-22683# Mechanical Technology, Inc., Latham, N. Y.
AI (ARTIFICIAL INTELLIGENCE) GAS TURBINE ROTOR DIAGNOSTICS Final Report, Apr. 1985 - Jul. 1986
B. AGGARWAL, J. TECZA, J. GIORDANO, and R. BRUNNER Nov. 1986 160 p
(Contract F33615-85-C-2513)
(AD-A178996; MTI-86-TR-36; AFWAL-TR-86-2072) Avail: NTIS HC A08/MF A01 CSCL 21E

With increased emphasis on improving the reliability and maintainability of gas turbine engines in the U.S. Air Force inventory and the need to operate aircraft from austere forward bases, new diagnostic tools are required. Such tools must provide reliable, consistent diagnoses and minimize training requirements for maintenance personnel. Knowledge-based diagnostic systems have the potential to meet these needs by improving the productivity of USAF maintenance personnel, affecting a standardized diagnostic approach at all maintenance facilities, and providing a wider dissemination of the benefits of accumulated USAF experience in gas turbine vibration diagnostics. Typical rotordynamic faults observed in gas turbine engines were surveyed to assess the extent of knowledge to diagnose rotordynamic faults. A set of generic rotordynamic faults was selected and a diagnostic strategy was developed for those faults. System configuration for a typical knowledge-based rotordynamic diagnostic system was defined based on the requirements identified during the survey. The diagnostic concepts developed were demonstrated using a laboratory test rig capable of having faults implanted in it. GRA

N87-22684# Naval Air Propulsion Test Center, Trenton, N.J.
STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN US COMMERCIAL AVIATION DURING 1981 Final Report
R. A. DELUCIA, J. T. SALVINA, and T. RUSSO Mar. 1987 27 p Prepared in cooperation with Federal Aviation Agency, Atlantic City, N.J.
(Contract DOT/FA71NA-AP98)
(DOT/FAA/CT-86/42; NAPC-PE-154C) Avail: NTIS HC A03/MF A01

Statistical data relating to gas turbine engine rotor failures which occurred during 1981 in commercial aviation service use are presented. The predominant failure involved blade fragments, 83 percent of which were contained. Three disk failures occurred and all were contained. Fifty-seven percent of the 136 failures occurred during the takeoff and climb stages of flight. Author

N87-22685*# Lockheed-California Co., Burbank.
FLIGHT AND ANALYTICAL INVESTIGATIONS OF A STRUCTURAL MODE EXCITATION SYSTEM ON THE YF-12A AIRPLANE Final Report
E. A. GOFORTH, R. C. MURPHY, J. A. BERANEK, and R. A. DAVIS Apr. 1987 295 p
(Contract NASA ORDER E-69204)
(NASA-CR-166623; H-1361; NAS 1.26:166623) Avail: NTIS HC A13/MF A01 CSCL 21E

A structural excitation system, using an oscillating canard vane to generate force, was mounted on the forebody of the YF-12A airplane. The canard vane was used to excite the airframe structural modes during flight in the subsonic, transonic, and supersonic regimes. Structural modal responses generated by the canard vane forces were measured at the flight test conditions by airframe-mounted accelerometers. Correlations of analytical and experimental aeroelastic results were made. Doublet lattice, steady state double lattice with uniform lag, Mach box, and piston theory all produced acceptable analytical aerodynamic results within the restrictions that apply to each. In general, the aerodynamic theory methods, carefully applied, were found to predict the dynamic behavior of the YF-12A aircraft adequately. Author

08

AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A87-36367
MULTI-RATE ADAPTIVE CONTROL WITH APPLICATIONS TO LATERAL DYNAMICS OF AIRCRAFT
M. DE LA SEN, J. L. MARCO, and C. LOPEZ-ABADIA (Pais Vasco, Universidad, Leioa, Spain) International Journal of Control (ISSN 0020-7179), vol. 45, March 1987, p. 759-778. refs
(Contract CAICYT PROJECT 968/84)

This paper deals with the development of multirate adaptive control algorithms with applications to the control of aircraft lateral dynamics. Several control channels work at different sampling rates to improve transient behavior and disturbance rejection characteristics. Simulation results which corroborate the efficiency of the proposed algorithms are also given. Author

A87-36782
MISSION AND FLIGHT PATH PLANNING IN A TACTICAL AIR COMBAT COMPUTER [MISSIONS- UND FLUGBAHNPLANUNG IN EINEM TAKTISCHEN LUFTKAMPFPROZESSOR]
KLAUS H. WELL (DFVLR, Institut fuer Dynamik der Flugsysteme, Oberpfaffenhofen, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 260-267. In German. refs
(DGLR PAPER 86-156)

This paper describes algorithms for automatic aircraft steering against attacking missiles, optimally maneuvering aircraft, and nonmaneuvering aircraft. Simulation examples and results are reported which show the validity of suboptimal control laws as compared to optimal ones. Future developments in this field are considered. C.D.

A87-36792
MODELLING AIRCRAFT WING DOWNWASH TRANSIT TIME EFFECTS IN THE DIRECTION OF FLIGHT [ZUR MODELLIERUNG VON FLUEGELABWIND-LAUFZEITEINFLUESSEN IN DER FLUGZEUGLAENGSBEWEGUNG]
WULF MOENNICH (DFVLR, Institut fuer Flugmechanik, Brunswick, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 335-341. In German. refs
(DGLR PAPER 86-165)

The modelling of aircraft wing downwash transit time effects is examined using digital simulation of the aircraft's longitudinal motion. A derivative model and two new models are presented which simulate such effects by dead time approximation on the one hand and by the application of digital filter elements on the other. Power density spectra are compared in order to show that the new filter model provides a better approximation to the reference model, and that this range of validity is larger for the frequencies of the input vertical wind than for the derivative model. C.D.

A87-36799
WIND-TUNNEL TESTING OF AN ADAPTIVE FLUTTER-SUPPRESSION CONCEPT [WINDKANALERPROBUNG EINES ADAPTIVEN KONZEPTS ZUR FLATTERDAEMPFUNG]
H. HOENLINGER, D. MUSSMANN, and R. MANSER (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) DGLR, Jahrestagung, Munich, West Germany, Oct. 8-10, 1986, Paper. 15 p. In German. refs
(MBB-S-PUB-279)

The design concept and implementation of an adaptive active flutter controller for transport aircraft wings are discussed, and the results of wind-tunnel tests are presented in graphs. The operating principles of conventional active controllers (CACs) and the advantages of adaptive control are reviewed, and a design concept is described in which a CAC is operated by a computer which compares the phases between control-surface deflection and wing twisting with ideal values and adjusts the control signal every 3 sec. In tests on a model with flutter velocity 40 m/s in the DFVLR-Goettingen 3-m subsonic wind tunnel at up to 60 m/s, an adaptive controller using a constant target function is found to be effective, raising the flutter velocity to about 56 m/s, but no more effective than the CAC alone. Significantly improved performance is predicted for an adaptive controller using a stagnation-pressure-dependent target function. T.K.

A87-36841
THE LONGITUDINAL DYNAMIC STABILITY AND CONTROL OF A LARGE RECEIVER AIRCRAFT DURING AIR-TO-AIR REFUELLING
A. W. BLOY, K. A. M. ALI, and V. TROCHALIDIS (Manchester, Victoria University, England) Aeronautical Journal (ISSN 0001-9240), vol. 91, Feb. 1987, p. 64-71. refs

The longitudinal stability and control of a large receiver aircraft was considered during air-to-air refuelling. A simple horseshoe vortex was used to model the tanker wake and approximate expressions were derived for the additional aerodynamical derivatives due to the position and attitude of the receiver aircraft within the downwash field. These derivatives were shown to depend on the mean variation of downwash with vertical displacement at the receiver wing and tailplane. The mean downwash gradients, in turn, depend mainly on the vertical separation between the tanker and receiver aircraft and the ratio of the tanker-to-receiver aircraft wing spans. Solutions of the linearized equations of motion were obtained for a range of values of the downwash gradients. The large receiver aircraft, considered in the paper, typically exhibits two divergent modes which appear to be controlled in flight by frequent alternate movement of the elevators and engine throttle. Author

A87-36842
ON THE APPLICATION OF AXIOMATIC AERODYNAMIC MODELLING TO AIRCRAFT DYNAMICS. IV - TWO DIMENSIONAL DYNAMIC STALL
G. J. HANCOCK and J. S. Y. LAM (Queen Mary College, London, England) Aeronautical Journal (ISSN 0001-9240), vol. 91, Feb. 1987, p. 72-88. refs

An axiomatic aerodynamic model has been developed for the general motion of a two dimensional aerofoil as it passes in and out of stall, which gives realistic unsteady loads as compared to experimental values. A nonlinear set of aerodynamic derivatives with time delays have been derived from the axiomatic aerodynamics. 'Actual' and 'predicted' dynamic responses of an aerofoil, spring restrained in torsion, following an impulsive input show similar trends, including limit cycle oscillations, although there is a slight difference in frequency and a difference in the magnitude of the initial impulse required to trigger the limit cycle. Author

A87-38041#
EXPERIMENTAL VALIDATION OF THE CRITERION OF STALL-RELATED FLUTTER [VALIDATION EXPERIMENTALE DU CRITERE DE FLOTTEMENT DE DECROCHAGE]
JOHAN VAILLI (Societe Ratier-Figeac, Figeac, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 23rd, Modane, France, Nov. 12-14, 1986. 18 p. In French. refs
(AAAF PAPER NT 86-18)

Experiments using two helicopter profiles, NACA 16 and HOR, are performed to validate two methods previously proposed for the criterion of stall-related flutter in helicopter rotors. Stall is analyzed (using deformation measurements of the blade torsion) as a function of rotation velocity, and for different angles of incidence. The stability criterion is verified to within several percent for both profiles, validating its usefulness for the new HOR helicopter blades. R.R.

A87-39009#
SYNTHESIS OF TIME-INVARIANT LINEAR SYSTEMS UNDER DETERMINATE AND RANDOM EXCITATIONS [SINTEZ OPTIMAL'NYKH INVARIANTNYKH VO VREMENI LINEINYKH SISTEM PRI DETERMINIROVANNYKH I SLUCHAINYKH VOZDEISTVIIAKH]
L. N. BLOKHIN and A. A. TUNIK (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR) Kibernetika i Vychislitel'naia Tekhnika (ISSN 0454-9910), no. 69, 1986, p. 92-98. In Russian.

The synthesis of linear multidimensional systems for the stabilization of the programmed motion of flight vehicles is considered. The systems are optimal according to an accuracy

criterion with respect to random excitations and invariant with respect to determinate excitations. The main steps in the solution are outlined, and the solution algorithms are presented. B.J.

N87-21901# Technische Univ., Brunswick (West Germany). Inst. for Guidance and Control.
DESIGN CRITERIA FOR MULTI-LOOP FLIGHT CONTROL SYSTEMS
G. SCHAENZER *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 12 p Dec. 1986
Avail: NTIS HC A15/MF A01

The problems of design criteria and architecture of multiloop flight control systems for a realized system to achieve precise flight path guidance, safe and economic control of the aerodynamic flow (airspeed, angle of attack and lift coefficient control) and passenger comfort are discussed. Joint root locus and quality criteria design are presented. The structure of the presented multiloop flight control system consists of nonlinear open loop control for flight performance and flight management; superposed quasilinear state vector feedback; and six control surfaces (aileron, rudder, elevator, trim, throttle, direct lift/drag control). Author

N87-21957*# California Univ., Los Angeles.
AEROELASTIC EFFECTS IN MULTIROTOR VEHICLES. PART 2: METHODS OF SOLUTION AND RESULTS ILLUSTRATING COUPLED ROTOR/BODY AEROMECHANICAL STABILITY
C. VENKATESAN and P. P. FRIEDMANN Washington NASA Feb. 1987 184 p
(Contract NAG2-116)
(NASA-CR-4009; NAS 1.26:4009) Avail: NTIS HC A09/MF A01 CSCL 01C

This report is a sequel to the earlier report titled, Aeroelastic Effects in Multi-Rotor Vehicles with Application to Hybrid Heavy Lift System, Part 1: Formulation of Equations of Motion (NASA CR-3822). The trim and stability equations are presented for a twin rotor system with a buoyant envelope and an underslung load attached to a flexible supporting structure. These equations are specialized for the case of hovering flight. A stability analysis, for such a vehicle with 31 degrees of freedom, yields a total of 62 eigenvalues. A careful parametric study is performed to identify the various blade and vehicle modes, as well as the coupling between various modes. Finally, it is shown that the coupled rotor/vehicle stability analysis provides information on both the aeroelastic stability as well as complete vehicle dynamic stability. Also presented are the results of an analytical study aimed at predicting the aeromechanical stability of a single rotor helicopter in ground resonance. The theoretical results are found to be in good agreement with the experimental results, thereby validating the analytical model for the dynamics of the coupled rotor/support system. Author

N87-21958# Dynamic Controls, Inc., Dayton, Ohio.
RESEARCH AND DEVELOPMENT OF AIRCRAFT CONTROL ACTUATION SYSTEMS Final Report, May 1979 - Feb. 1985
CARL N. ALLBRIGHT, GAVIN D. JENNEY, HARRY W. SCHREADLEY, and WILLIAM G. TALLEY Dec. 1986 175 p
(Contract F33615-79-C-3602)
(AD-A177491; AFWAL-TR-86-3070) Avail: NTIS HC A08/MF A01 CSCL 01C

Described are the design and test of a multipurpose actuation test rig to be used for loaded evaluation of actuation systems with rotary outputs and/or integrated as part of wing structure. It also describes a hydromechanical flutter damping module for an F-4 stabilator actuator. The module incorporates design improvements based on previous test results. Development and test results of a linear force motor based on a moving magnet concept, and the measured performance characteristics of the concept over a range of parameter variations are presented. A method of force enhancement for direct drive force motors and the corresponding test results applied to a moving coil force motor are described. The concept is based on applying a limited time duration pulse to the force motor in order to increase the force output when required. The logic technique used to initiate the pulse application is presented. Applying a digital computer as a controller for an analog electrohydraulic control system requires consideration of the interface used. The effect of a pulse width modulation interface on the life of analog electrohydraulic hardware is presented. There is a potential for reducing the pumping capacity of an aircraft's flight control hydraulic system by using accumulators to store hydraulic energy. The results of a study using this approach and an F-16 simulation are presented. GRA

N87-21959# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
QFT (QUANTITATIVE FEEDBACK THEORY) DIGITAL FLIGHT CONTROL DESIGN AS APPLIED TO THE AFTI/F16 M.S. Thesis
DEAN L. SCHNEIDER Dec. 1986 340 p
(AD-A177744; AD-E751201; AFIT/GE/ENG/86D-4) Avail: NTIS HC A15/MF A01 CSCL 09D

Quantitative Feedback Theory (QFT) has been shown to adequately synthesize compensators for a variety of continuous time systems. An investigation was made to extend QFT to sampled-data systems via a pseudo-continuous time approach. This investigation resulted in the satisfaction of specifications as in the continuous case for a transport aircraft (KC-135) but not for a fighter aircraft (AFTI/F-16). This thesis attempts to extend QFT to the discrete multiple-input, multiple-output (MIMO) problem by utilizing the w' transformation from the discrete z-domain plant. The remainder of the first chapter presents a statement and the scope of the problem, the assumptions made, the approach taken, and the sequence of presentation for the rest of the thesis. Throughout the thesis, the author assumes the reader is familiar with continuous MIMO QFT techniques and, therefore, only differences from the continuous design procedure are noted. GRA

N87-21960*# Minnesota Univ., Minneapolis.
EIGENSPACE TECHNIQUES FOR ACTIVE FLUTTER SUPPRESSION
WILLIAM L. GARRARD, BRADLEY S. LIEBST, and JEROME A. FARM Washington NASA Jun. 1987 73 p
(Contract NAG1-217)
(NASA-CR-4071; NAS 1.26:4071) Avail: NTIS HC A04/MF A01 CSCL 01C

The use of eigenspace techniques for the design of an active flutter suppression system for a hypothetical research drone is discussed. One leading edge and two trailing edge aerodynamic control surfaces and four sensors (accelerometers) are available for each wing. Full state control laws are designed by selecting feedback gains which place closed loop eigenvalues and shape closed loop eigenvectors so as to stabilize wing flutter and reduce gust loads at the wing root while yielding accepatable robustness and satisfying constrains on rms control surface activity. These controllers are realized by state estimators designed using an eigenvalue placement/eigenvector shaping technique which results in recovery of the full state loop transfer characteristics. The resulting feedback compensators are shown to perform almost as well as the full state designs. They also exhibit acceptable performance in situations in which the failure of an actuator is simulated. B.G.

N87-21961*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A SIMULATION INVESTIGATION OF SCOUT/ATTACK HELICOPTER DIRECTIONAL CONTROL REQUIREMENTS FOR HOVER AND LOW-SPEED TASKS
COURTLAND C. BIVENS (Army Aviation Research and Development Command, Moffett Field, Calif.) and JOSEPH G. GUERCIO Mar. 1987 299 p
(NASA-TM-86755; A-85257; USAAVSCOM-TR-85-A-11; NAS 1.15:86755) Avail: NTIS HC A13/MF A01 CSCL 01C

A piloted simulator experiment was conducted to investigate directional axis handling qualities requirements for low speed and

hover tasks performed by a Scout/Attack helicopter. Included were the directional characteristics of various candidate light helicopter family configurations. Also, the experiment focused on conventional single main/tail rotor configurations of the OH-58 series aircraft, where the first-order yaw-axis dynamic effects that contributed to the loss of tail rotor control were modeled. Five pilots flew 22 configurations under various wind conditions. Cooper-Harper handling quality ratings were used as the primary measure of merit of each configuration. The results of the experiment indicate that rotorcraft configurations with high directional gust sensitivity require greater minimum yaw damping to maintain satisfactory handling qualities during nap-of-the-Earth flying tasks. It was also determined that both yaw damping and control response are critical handling qualities parameters in performing the air-to-air target acquisition and tracking task. Finally, the lack of substantial yaw damping and larger values of gust sensitivity increased the possibility of loss of directional control at low airspeeds for the single main/tail rotor configurations. Author

N87-22622*# Princeton Univ., N. J. Dept. of Mechanical and Aerospace Engineering.

STABILITY BOUNDARIES FOR COMMAND AUGMENTATION SYSTEMS

P. C. SHRIVASTAVA *In* NASA. Langley Research Center Joint University Program for Air Transportation Research, 1984 p 161-176 May 1987

Avail: NTIS HC A08/MF A01 CSCL 01C

The Stability Augmentation System (SAS) is a special case of the Command Augmentation System (CAS). Control saturation imposes bounds on achievable commands. The state equilibrium depends only on the open loop dynamics and control deflection. The control magnitude to achieve a desired command equilibrium is independent of the feedback gain. A feedback controller provides the desired response, maintains the system equilibrium under disturbances, but it does not affect the equilibrium values of states and control. The saturation boundaries change with commands, but the location of the equilibrium points in the saturated region remains unchanged. Nonzero command vectors yield saturation boundaries that are asymmetric with respect to the state equilibrium. Except for the saddle point case with MCE control law, the stability boundaries change with commands. For the cases of saddle point and unstable nodes, the region of stability decreases with increasing command magnitudes. Author

N87-22674# British Aerospace Public Ltd. Co., Preston (England).

IMPROVED COMBAT PERFORMANCE USING RELAXED STATIC STABILITY AND A SPIN PREVENTION SYSTEM (FBW JAGUAR)

J. R. NELSON and T. D. SMITH *In* AGARD Improvement of Combat Performance for Existing and Future Aircraft 8 p Dec. 1986

Avail: NTIS HC A07/MF A01

The theoretical performance benefits that can be obtained by designing an aircraft that is naturally unstable in pitch and artificially stabilized by use of active control technology including an integral stall departure and spin prevention/g limiting function are described. How many of these benefits have been successfully demonstrated during flight trials on the FBW Jaguar demonstrator aircraft is discussed. The flight trials are briefly discussed including the results of the stall departure and spin prevention system assessment with examples of severe dynamic combat maneuvers made possible by such a system. The combination of leading edge wing strakes and longitudinal instability gave improvements in aircraft turn rate, acceleration, and field performance, thus providing a practical demonstration of many of the theoretical benefits described earlier. The FBW Jaguar flight control system was designed from the outset as a production system with the aim of identifying production clearance procedures so this experience leads straight into new combat aircraft such as the EFA. Author

N87-22686# Messerschmitt-Boelkow-Blohm G.m.b.H., Ottobrunn (West Germany). Unternehmensbereich Apparate.

ELECTROMAGNETIC INTERFERENCE (EMI) FAULT PREVENTION AND SELF RECOVERY OF DIGITAL FLIGHT CONTROL SYSTEMS

MICHAEL STOCK 1986 20 p Presented at the 12th European Rotorcraft Forum, Garmisch-Partenkirchen, West Germany, 22-25 Sep. 1986 Sponsored by DGLR

(MBB-UD-483/86; ETN-87-99928) Avail: NTIS HC A02/MF A01

Ways to achieve helicopter digital flight control system reliability and survivability are shown. Microcomputer system failures caused by electromagnetic interference (EMI) and their impact on flight control are considered. Ways to ensure self recovery after EMI induced faults are outlined. A digital flight control system designed with respect to EMI problems and flight tested on a BK-117 is presented. ESA

N87-22687# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

EVALUATION OF NUMERATOR LEAD EFFECTS ON AIRCRAFT HANDLING QUALITIES M.S. Thesis

DAVID W. EIDSAUNE Nov. 1986 137 p

(AD-A179388; AFIT/GAE/AA/86J-2) Avail: NTIS HC A07/MF A01 CSCL 01A

Results of a combined analytical/flight test evaluation to investigate the effects of short period zero (T theta 2) on aircraft handling qualities are presented. Two optimal pilot models were used for the analytical portion. 1/T theta 2 was varied from 0.1 to 10 for each 4 different short period configurations. Flight testing was accomplished in the variable stability NT-33A aircraft, over a range of 1/T theta 2 values at one short period configuration. A pitch tracking task was used to generate RMS pitch errors for both the analytical and flight test phase. Cooper-Harper ratings were also collected during the flight test. Analytical results showed similar trends for all short period configurations, with pilot tracking task performance degrading at low 1/T theta 2 values. The bandwidth criterion was of limited use in predicting handling qualities levels based on T theta 2 variations alone. The dc gain variations produced minimal differences in pilot performance. Overall evaluation results indicate that T theta 2 placement is an important factor in short period handling qualities and should be included in future revisions to MIL-F-87 85C. GRA

N87-22688# Naval Postgraduate School, Monterey, Calif.

DYNAMIC STALL CALCULATIONS USING A NAVIER-STOKES SOLVER M.S. Thesis

JAMES E. VALDES Dec. 1986 120 p

(AD-A178566) Avail: NTIS HC A06/MF A01 CSCL 20D

A Navier Stokes problem solver is installed and verified on the Cray X/MP-48 computer and is used to calculate the flow field about a NACA 0012 airfoil oscillating in pitch. Surface pressure distributions and integrated lift, pitching moment, and drag coefficients versus angle of attack are compared to existing experimental data for two cases, involving deep dynamic stall and fully attached flow at and below a freestream Mach number of .3. The flow field about the oscillating airfoil is investigated through the study of contour plots of pressure, density, Mach number, and stream function. The effect of turbulence modeling is explored through use of the Baldwin Lomax model and a modification designed to prevent underprediction by repeating the deep stall simulation at one-tenth the experimental Reynolds number and Mach numbers of .3 and 5. The latter conditions are intended for comparison with the results of wind tunnel experiments. GRA

N87-22689# Army Aviation Research and Development Command, Moffett Field, Calif. Aeroflightdynamics Directorate.
CORRELATION OF ANALYTICAL CALCULATIONS FROM GRASP (GENERAL ROTORCRAFT AEROMECHANICAL STABILITY PROGRAM) WITH TORSIONALLY-SOFT ROTOR DATA
DONALD L. KUNZ and DEWEY H. HODGES 1987 18 p
(AD-A178881) Avail: NTIS HC A02/MF A01 CSCL 20D

As a part of the continuing effort to develop and validate the General Rotorcraft Aeromechanical Stability Program (GRASP), a correlation study is presented to compare the frequency, moment, and stability data for a model-scale, torsionally-soft, helicoptor rotor with GRASP numerical calculations. The hierarchical representation of the model rotor is discussed along with the calculations of the vacuum frequencies, the steady-state blade moments in air, and the aeroelastic stability. Correlation is generally quite good. The GRASP predictions of the first vacuum flap frequencies are outstanding and the first vacuum lag and torsion frequencies correlate reasonably well with the experimental data. Consistently outstanding results are obtained for all of the steady blade moments. The calculations of stability data are in general as good as those made by other programs, but are not quite as good as anticipated. GRA

N87-22690*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
FREQUENCY-RESPONSE IDENTIFICATION OF XV-15 TILT-ROTOR AIRCRAFT DYNAMICS
MARK B. TISCHLER May 1987 191 p Prepared in cooperation with Army Aviation Systems Command, Moffett Field, Calif.
(NASA-TM-89428; A-87103; NAS 1.15:89428) Avail: NTIS HC A09/MF A01 CSCL 01C

The timely design and development of the next generation of tilt-rotor aircraft (JVX) depend heavily on the in-depth understanding of existing XV-15 dynamics and the availability of fully validated simulation models. Previous studies have considered aircraft and simulation trim characteristics, but analyses of basic flight vehicle dynamics were limited to qualitative pilot evaluation. The present study has the following objectives: documentation and evaluation of XV-15 bare-airframe dynamics; comparison of aircraft and simulation responses; and development of a validated transfer-function description of the XV-15 needed for future studies. A nonparametric frequency-response approach is used which does not depend on assumed model order or structure. Transfer-function representations are subsequently derived which fit the frequency responses in the bandwidth of greatest concern for piloted handling-qualities and control-system applications. Author

N87-22691*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DIGITAL CONTROL OF HIGHLY AUGMENTED COMBAT ROTORCRAFT
MARK B. TISCHLER May 1987 165 p
(NASA-TM-88346; A-86369; NAS 1.15:88346;
USAAVSCOM-TR-87-A-5) Avail: NTIS HC A08/MF A01 CSCL 01C

Proposed concepts for the next generation of combat helicopters are to be embodied in a complex, highly maneuverable, multiroled vehicle with avionics systems. Single pilot and nap-of-the-Earth operations require handling qualities which minimize the involvement of the pilot in basic stabilization tasks. To meet these requirements will demand a full authority, high-gain, multimode, multiply-redundant, digital flight-control system. The gap between these requirements and current low-authority, low-bandwidth operational rotorcraft flight-control technology is considerable. This research aims at smoothing the transition between current technology and advanced concept requirements. The state of the art of high-bandwidth digital flight-control systems are reviewed; areas of specific concern for flight-control systems of modern combat are exposed; and the important concepts are illustrated in design and analysis of high-gain, digital systems with a detailed case study involving a current rotorcraft system. Approximate and exact methods are explained and illustrated for treating the important concerns which are unique to digital systems. Author

N87-22692*# Alphatech, Inc., Burlington, Mass.
INTEGRATED RESTRUCTURABLE FLIGHT CONTROL SYSTEM DEMONSTRATION RESULTS
JEROLD L. WEISS and JOHN Y. HSU May 1987 134 p
(Contract NAS1-17411)
(NASA-CR-178305; NAS 1.26:178305; TR-335) Avail: NTIS HC A07/MF A01 CSCL 01C

The purpose of this study was to examine the complementary capabilities of several restructurable flight control system (RFCS) concepts through the integration of these technologies into a complete system. Performance issues were addressed through a re-examination of RFCS functional requirements, and through a qualitative analysis of the design issues that, if properly addressed during integration, will lead to the highest possible degree of fault-tolerant performance. Software developed under previous phases of this contract and under NAS1-18004 was modified and integrated into a complete RFCS subroutine for NASA's B-737 simulation. The integration of these modules involved the development of methods for dealing with the mismatch between the outputs of the failure detection module and the input requirements of the automatic control system redesign module. The performance of this demonstration system was examined through extensive simulation trials. Author

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tubes; and aircraft engine test stands.

A87-35343
AN ULTRAHIGH SPEED CAMAC INTERFACE FOR A LARGE FLIGHT SIMULATOR SYSTEM
ROBERT T. CLEARY (Kinetic Systems Corp., Lockport, IL) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-22, Sept. 1986, p. 618-627. refs

The real-time simulation subsystem (RTSS) at NASA Langley consists of several CDC CYBER computers and over 20 flight simulation sites. The current simulator interface system at NASA-Langley was installed in 1968 and uses centrally located analog and discrete conversion equipment. Of the alternatives studied by NASA for a replacement RTSS, only the network and input/output (I/O) system conforming to the international Computer Automated Measurement and Control (CAMAC) standards meets their requirements. The CAMAC serial highway provides a distributed I/O system with an extremely high data throughput (approaching 24,000,000 information bits/per sec). The CAMAC system uses analog-to-digital converters (ADCs), digital-to-analog converters (DACs), and synchro converters with 16 bits of resolution to give the needed system performance. The time to acquire data from 80 16-bit ADCs and 960 discrete inputs and transfer them to the CYBER central memory is less than 320 microsec. Similarly, the time from CYBER central memory to the setting of 256 16-bit DACs and 960 discrete outputs is less than 650 microsec. Author

A87-36281
WEIGHT AND CENTER OF GRAVITY DETERMINATION ON GROUND AND AIRBORNE
H. DRACHENBERG (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 36 p. refs
(SAWE PAPER 1695; MBB-TE444-B-254/04/08)

The history and present status of programs to develop systems for weight and center-of-gravity determination for aircraft are

described. Messerschmitt-Boelkow-Blohm, has been working on weight and balance systems since 1978, beginning with the A310-200 aircraft and continuing with the A310-300 and A310-600; a system for the A320 has been defined and is now in development. Preliminary tests show that the sensor principle and the placement of sensors on the landing gear are most critical for on-ground weight and balance determination. For the A310-300, it became necessary to be able to determine the center of gravity position in flight. A system configuration is described that allows actual in-flight center of gravity determination and permits the position to be controlled and manipulasted by moving fuel in a trim-tank system. D.H.

A87-36283
AUTOMATICAL LOADSHEET PREPARATION
ED GALJAAR (KLM Royal Dutch Airlines, Schiphol, Netherlands) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 34 p.
(SAWE PAPER 1697)

It is impossible for large airlines to produce loadsheets, flight plans, etc. manually where this information is needed with such high frequency. Using a computerized system it is now possible to produce all the weight and balance data for each departure - quickly, economically, accurately, and within the safety limits. The system controls the assembly of all load data such as passengers, cargo, mail, and operational items to ensure that the total aircraft load complies with save weight and balance limits. The load planning process is undertaken automatically by the system, and a number of checks are monitored (information on time, maximum weight not exceeded, aircraft in trim, system discrepancies). Finally the load sheet is printed out, showing load distribution, seating conditions, fuel data, weight and balance limits, and weight and balance actual data. Flow charts and tabulated data are given. D.H.

A87-36286
EDWARDS' AUTOMATED WEIGHT AND BALANCE SYSTEM
DAVE FRAILEY (USAF, Flight Test Center, Edwards AFB, CA) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 29 p. refs
(SAWE PAPER 1702)

The Edwards' AFB Automated Weight and Balance System, developed in-house at the Weight and Thrust Section of the Technical Facilities Branch, is described. The system was developed to be applicable to the more than 80 aircraft maintained at Edwards. The base language used is Fortran, augmented with a comprehensive assembly language library of extensive keyboard and video functions. Topics covered include concepts, data file structure, programming considerations, factors of user-friendliness, and form generation concepts. The perceived advantages have led to wide acceptance: the Edwards Automated Weight and Balance System is in distribution to more than 110 organizations. D.H.

A87-36294
A FULLY AUTOMATIC MASS PROPERTIES MACHINE
RICHARD BOYNTON (Space Electronics, Inc., Meriden, CT) and DURWOOD WOODY GREEN (Sandia National Laboratories, Livermore, CA) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 35 p.
(SAWE PAPER 1723)

A fully automated mass properties machine is described which measures center of gravity, product of inertia, and moment of inertia. All three measurements can be made from a remote location without the need for any operator interaction with the machine. The machine produces an illustrated report of test data, complete with a drawing of the test part which shows the datum reference points. Unbalance reduction ratios of better than 99 percent are generally achievable, so the object under test can usually be balanced in a single run. CG measurement accuracy is typically better than 0.001 inch. Special features include: calculation of principal axis tilt, ability to map the available locations for unbalance correction weights (so that the machine will not specify a disallowed location), prediction of unbalance force at the selected operating speed from measurements made at a slow speed, and the safeguarding of secret data. D.H.

A87-36296
PRINCIPLES AND PRACTICES FOR ACCURATE LOAD CELL MEASUREMENTS
JOHN C. CORLISS (U.S. Navy, Naval Weapons Station, Pomona, CA) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 14 p.
(SAWE PAPER 1725)

It is shown how load-cell weighing systems, if properly used, can produce convenient and dependable force and mass measurements, when accuracy on the order of plus or minus 0.05 percent is required. Factors tending to degrade performance and practices developed to enhance accuracy are examined. Although tension loading is always the loading method of choice, when compression loading is unavoidable there are preferred arrangements. In judging the quality of load cells, one must consider terms such as linearity, hysteresis, temperature compensation, and repeatability; the meaning, relevance, and physical basis for these concepts are explained. Also covered are some subtle effects arising in the measurement and indication of voltage ratios. D.H.

A87-36943
MEASUREMENT OF MODEL DEFORMATIONS IN WIND TUNNELS [MESURE DES DEFORMATIONS DES MAQUETTES EN SOUFFLERIE]
MR. CHARPIN, MR. ARMAND, and MR. SELVAGGINI (ONERA, Chatillon-sous-Bagneux, France) (NATO, AGARD, Meeting on Static Aeroelasticity Effects on High-Performance Aircraft, 63rd, Athens, Greece, Oct. 1, 2, 1986) L'Aeronautique et l'Astronautique (ISSN 0001-9275), no. 120, 1986, p. 45-55. In French.

Various techniques used at ONERA for the wind tunnel measurement of the deformation of models undergoing aerodynamic and body loading are presented. Photography of reflecting targets is used to measure trailing edge deformation. Global torsion measurement of a wing at its wing tip is performed by the torsiometer measurement of the angle between the incident and reflected laser beam. An example of the determination of airfoil trailing edge deformation by tracking the position of light sources with an optical detector is presented. Finally, a technique for computing the strain from stress measurements is presented and demonstrated with a helicopter rotor blade model. R.R.

A87-38033#
VALIDATION OF CRYOGENIC TESTS AT THE T2 WIND TUNNEL [QUALIFICATION D'ESSAIS EN AMBIANCE CRYOGENIQUE A LA SOUFFLERIE T2]
A. SERAUDIE, A. BLANCHARD, and J. B. DOR (ONERA, Centre d'Etude et de Recherches de Toulouse, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 23rd, Modane, France, Nov. 12-14, 1986. 49 p. In French. refs
(AAAF PAPER NT 86-07)

Test methods and measurement techniques of the high-Reynolds-number (up to 30 million), high-pressure, cryogenic T2 wind tunnel are discussed. Velocity and pressure fluctuation measurements are obtained with high-bandpass pressure probes and hot-film probes. Stagnation and static pressure probes with short response times are used to investigate wakes, and unsteady static pressure measurements, with sensors placed at the profile boundary, are obtained to study buffeting. Transition positions are detected using IR thermography, stagnation-pressure and longitudinal sounding, thermocouple measurements of boundary temperatures, and oil-film parietal visualizations. The measurement of aerodynamic coefficents of a model using a five-component balance is also discussed. R.R.

A87-38036#
COMPARISON OF SCALING RESULTS OBTAINED FOR A SWEPT-BACK WING IN A HYDRODYNAMIC TUNNEL AND IN A WIND TUNNEL [COMPARAISON DE RESULTATS DE PESEES EFFECTUEES SUR UNE AILE EN FLECHE, EN TUNNEL HYDRODYNAMIQUE ET EN SOUFFLERIE]
B. CHEZLEPRETRE, A. ROUSSEAU, and Y. BROCARD (Societe Bertin et Cie, Plaisir, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 23rd, Modane, France, Nov. 12-14, 1986. 37 p. In French. refs
(AAAF PAPER NT 86-12)

A comparison of scaling results obtained for a 55-deg swept-back wing in a hydrodynamic tunnel and in a wind tunnel validates the use of the high-Reynolds-number hydrodynamic tunnel for aerodynamic applications. Characteristics of the wing model, and the various geometric configurations used, are first discussed. Comparison of the scaling results shows a similar close-coupled canard effect for both test methods. Visualizations obtained in the hydrodynamic tunnel show a good correlation between the characteristic physical phenomena of the development of the apex vortex and the development of the aerodynamic coefficients. The vortex wake is analyzed by laser velocimetry. R.R.

N87-21962# Air War Coll., Maxwell AFB, Ala.
THE IMPACT OF TECHNOLOGY ON FLIGHT SIMULATION
ANTHONY J. TOLIN May 1986 26 p
(AD-A177861; AU-AWC-86-213) Avail: NTIS HC A03/MF A01 CSCL 05I

Remarks on the debate of flying time versus simulator time introduce a discussion on the impact of technology in flight simulation. A brief look at the history of flight simulators is followed by a more detailed analysis of where the Air Force is today with regard to flight simulation. This analysis looks at the advantages of simulators, the choice between motion and visual systems, and addresses several problems and issues. After a discussion of the future in flight simulation, the conclusion that simulation is here to stay as a complement, not a replacement for, actual flying hours is developed. GRA

N87-21963*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ONE-FIFTIETH SCALE MODEL STUDIES OF 40-BY 80-FOOT AND 80-BY 120-FOOT WIND TUNNEL COMPLEX AT NASA AMES RESEARCH CENTER
GENE I. SCHMIDT, VERNON J. ROSSOW, JOHANNES VANAKEN (Kansas Univ., Lawrence.), and CYNTHIA L. PARRISH Apr. 1987 49 p
(NASA-TM-89405; A-86438; NAS 1.15:89405) Avail: NTIS HC A03/MF A01 CSCL 14B

The features of a 1/50-scale model of the National Full-Scale Aerodynamics Complex are first described. An overview is then given of some results from the various tests conducted with the model to aid in the design of the full-scale facility. It was found that the model tunnel simulated accurately many of the operational characteristics of the full-scale circuits. Some characteristics predicted by the model were, however, noted to differ from previous full-scale results by about 10%. Author

N87-21964# Texas A&M Univ., College Station. Transportation Inst.
CRITERIA FOR ASPHALT-RUBBER CONCRETE IN CIVIL AIRPORT PAVEMENTS. VOL. 2: EVALUATION OF ASPHALT-RUBBER CONCRETE Final Report, Sep. 1983 - Mar. 1987
DENISE M. HOYT, ROBERT L. LYTTON, and FREDDY L. ROBERTS Mar. 1987 241 p
(Contract DTFA01-83-C-30076)
(DOE/FAA/PM-86/39-VOL-2) Avail: NTIS HC A11/MF A01

Asphalt-rubber concrete and an asphalt concrete control were tested in the laboratory and materials characterizations were generated, including Marshall Stability, resilient modulus, fatigue and fracture properties, creep compliance, and permanent deformation properties. The characterization parameters and an airport runway model for a municipal airport were input into the modified ILLIPAVE computer program for analysis of rutting and cracking damage and the relative lives of the materials in each of four climatic zones. An economic evaluation was then performed comparing the costs and service lives of each material in each zone. Author

N87-21965# Pavement Consultancy Services, Inc., College Park, Md.
PERFORMANCE OF CRACKED AND SEATED RIGID AIRPORT PAVEMENTS Final Report
G. R. RADA and M. W. WITCZAK Apr. 1987 81 p
(Contract DTFA01-86-P-08004)
(DOT/FAA/PM-87/4) Avail: NTIS HC A05/MF A01

Despite the growing popularity of the crack and seat technique, little guidance is available for use in evaluating and designing overlays for cracked and seated airfield pavements. A case study was undertaken to compare in-situ characteristics and overlay requirements of three different pavement sections at Suffolk Municipal Airport, Va. Nondestructive testing (NDT) was used to determine the in-situ pavements properties and visual surveys were conducted to assess the condition rating of the pavements. The results of the NDT testing program were used to predict and compare the Portland Cement Concrete (PCC) layer moduli and the design Asphaltic Concrete (AC) overlays. The results indicate that: (1) while the use of the crack and seat technique appears to be effective, reflective cracking is not eliminated; (2) the strength of the PCC layer is significantly reduced after cracking and seating and hence, thicker AC overlays are required; and (3) a greater degree of cracking before placing the overlay would have been useful. Author

N87-21968# National Aerospace Lab., Tokyo (Japan).
AN EXPERIMENTAL STUDY ON THE THRESHOLD OF ROLL PERCEPTION
HIROYASU KAWAHARA, NAOKI ISU, and TAKAO MIMURA 1986 24 p In JAPANESE; ENGLISH summary
(NAL-TR-905; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

In order to improve the driving algorithm of the moving base of a flight simulator, some basic characteristics concerning perception of roll motion were investigated. Thresholds of roll perception were examined by rolling subjects from an upright position and from several angles of initial tilt to upright. It was confirmed that the threshold of roll perception is represented by the roll angle in the range in which flight simulators are usually driven. The threshold of roll detection from an upright position was 0.78 deg. Those from a position of initial tilt increased in proportion to the angle of the initial tilt. Sensation of static tilt was also estimated by asking subjects to indicate the vertical direction. The tilt angle was perceived to be larger than the physical tilt in the range of less than 7 deg., while it was perceived to be smaller at larger angles. Author

N87-21969# National Aerospace Lab., Tokyo (Japan).
TRIAL MANUFACTURE OF NAL 0.1M X 0.1M TRANSONIC CRYOGENIC WIND TUNNEL
KAZUAKI TAKASHIMA, HIDEO SAWADA, TAKEO AOKI, and SHIGEO KAYABA 1986 58 p In JAPANESE; ENGLISH summary
(NAL-TR-910; ISSN-0389-4010) Avail: NTIS HC A04/MF A01

In order to study the cryogenic wind tunnel, in which high Reynolds number tests can be conducted, a small transonic cryogenic wind tunnel was constructed. The construction and the operational results are described. This small cryogenic wind tunnel, with a test section of 0.1m x 0.1m, was built to ascertain the basic design specifications for a large transonic cryogenic wind tunnel which will be constructed in the future, and also to gain skill in operating the cryogenic wind tunnel. The capability of this wind tunnel is from stagnation temperature down to -173 C, for Mach numbers ranging from 0.4 to 1.02 and for a unit Reynolds number up to 1.3 x 1 million/cm with more than one hour running time. The design concept is first briefly given, then, the complete system i.e., the wind tunnel, the liquid nitrogen supply system, the

gas nitrogen exhaust system, the thermal insulation device, the fan and the drive motor and the instrumentation and operating system are described in detail. Finally, the experimental results are discussed. The conclusion is that cryogenic wind tunnel operation can be safely and successfully conducted. Author

N87-22354*# United Air Lines, Inc., Denver, Colo.
IMPLEMENTATION OF TURBULENCE MODELS INTO SIMULATORS
ROBERT L. IRELAND *In* NASA. Langley Research Center Atmospheric Turbulence Relative to Aviation, Missile and Space Programs p 179-180 Apr. 1987
Avail: NTIS HC A12/MF A01 CSCL 14B

Simulation of turbulence as it relates to the flight training environment is discussed in general terms. Simulators that put random white noise into the system and simulators that put random motion into the equations of motion are discussed, as are simulators that incorporate pitch and roll moments into vertical turbulence. Wind shear models and simplified models of microburst phenomena are covered. R.J.F.

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; space communications; spacecraft communications; command and tracking; spacecraftdesign; testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A87-37400#
TELEMETRY INTEGRATED PROCESSING SYSTEM OPERATIONAL OVERVIEW
JOHN D. MCCULLOCH (Federal Electric Corp., Vandenberg AFB, CA) IN: ITC/USA/'86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 355-365.

The Telemetry Integrated Processing System (TIPS) at the U.S. Air Force Western Space and Missile Center (WSMC), Vandenberg AFB, CA, is a large- scale, computer-based, telemetry decommutation and data-processing system. This system is utilized to process telemetry data from numerous missile and aircraft programs supported at the WSMC. This paper presents an overview of the operational system as it exists today. Hardware and software components are discussed. A presentation of the standard no-development-cost features available to range users is made. A summary of the current missile/aircraft telemetry systems that must be supported is included along with some of the special processing developed for these systems. Author

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; propellants and fuels; and materials processing.

A87-35281#
COMPOSITE STRUCTURE DESIGN
G. HELLARD (Aerospatiale, Toulouse, France) IN: BASTART 85 - Bonded aircraft structures, technical application and repair techniques; Proceedings of the Workshop, Bremen, West Germany, Jan. 22-24, 1985 . Bremen, West Germany, Fraunhofer-Institut fuer angewandte Materialforschung, 1985, 19 p.

An account is given of state-of-the-art design principles for composite primary and secondary structural elements applicable to commercial aircraft airframes. After noting the essentials of reinforcing fiber and matrix resin selection, attention is given to the choice of prepreg tape or fabric layup methods and the applicability of hybrid reinforcements. Applications encompass multiphase- or cocuring-processed honeycomb core sandwich structures, and self-stiffened and multirib box monolithic structures, as found in current airliners' airbrakes, ailerons, and wing flaps. Attention is given to the difficulties posed by ply layup procedures, the bonding of entire assemblies, and CFRP/metal assembly joints. O.C.

A87-35669
GEAR MATERIALS IN HELICOPTER TRANSMISSIONS
D. P. DAVIES (Westland Helicopters, Ltd., Yeovil, England) Metals and Materials (ISSN 0266-7185), vol. 2, June 1986, p. 342-348. refs

An assessment is made of the state-of-the-art in helicopter transmission gear materials technology, with a view to advanced systems' mechanical and metallurgical requirements and the comparative performance levels of more conventional materials and design practices. A typical advanced gearing carburized steel, BS S156, has an ultimate tensile strength of 1300 MPa and a surface hardness of 650 HV, with good forgeability, machinability and hardenability. Case hardening for this carburized steel proceeds to a minimum depth of 12 mm, and allows it to withstand Izod impact energies of the order of 30 ft-lbs in hot oil elements of 130 C. Attention is given to future transmission design criteria, and the prospective performance of future carburizing and nitriding steels at high temperatures. O.C.

A87-36277
ALUMINUM MATRIX COMPOSITE STRUCTURES FOR FIGHTER AIRCRAFT
J. P. SORENSEN (McDonnell Aircraft Co., Saint Louis, MO) and C. R. WAITZ (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 13 p. refs
(SAWE PAPER 1689)

A history of the development of aluminum matrix composites (AMCs) is given with regard to prospects for using such materials on high performance fighter aircraft. A study has shown that built-up AMC designs cost more and weight more than those that incorporate the AMC material into integrally stiffened structures. Comparison with other materials, however, showed that the relative advantage of ASMC designs depends on the type of structure being replaced. The weight savings of an integrally stiffened AMC wing skin over one machined from plate is significant while only a modest savings could be made over the more sophisticated boron/epoxy/honeycomb tail structures. On the other hand, cost comparisons revealed just the opposite effect: the cost of the aluminum wing skins would increase if replaced with AMC; the cost of the titanium wing skins would remain about the same; and boron/epoxy/honeycomb could be replaced for less money. F-15

components were used to evaluate the aluminum matrix composite concepts. D.H.

A87-36278
TORLON ENGINEERED PARTS CUT WEIGHT IN HALF
JOHN J. MCMULLAN (Amoco Chemicals Corp., Seymour, IN) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 15 p.
(SAWE PAPER 1690)

Significant weight savings are possible in the aerospace industry by substituting the engineering polymer Torlon for metal. Estimates have been made that in many applications a 1-pound saving is worth $150 to $500. In applications where substitution is made without design changes, weight savings of 50 percent are typical for replacing aluminum, and 80 percent for steel. When the design is modified to make the Torlon part equivalent to the original metal design in strength or stiffness, the figures are lower but still impressive. With injection molding, design features (such as coring) that are not economically feasible with metals are permitted, reducing weight further. Torlon's strength and stiffness remain high over a temperature range from -196 C to +260 C (-321 F to +500 F); it is resistant to attack by aviation fluids and most other chemicals. Other characteristics include low expansion coefficients, lions-term dimensional stability, and low flammability and smoke long-term dimensional stability, and low flammability and smoke generation. D.H.

A87-36578
THE EFFECT OF OPERATION FACTORS ON THE FUEL SYSTEM OF AIRCRAFT [VLIIANIE EKSPLUATATSIONNYKH FAKTOROV NA TOPLIVNUIU SISTEMU SAMOLETOV]
VLADISLAV TROFIMOVIC VASILENKO and ZHAN SERGEEVICH CHERNENKO Moscow, Izdatel'stvo Mashinostroenie, 1986, 184 p. In Russian. refs

The principal specifications and properties of aviation fuels are examined in relation to the conditions of aircraft operation, including climatic and metereological factors. Topics discussed include low-temperature properties of fuels for gas-turbine engines; impurities and water in fuels and their effect on the performance of the fuel system; the effect of subzero temperatures on the operation of the fuel system; and thermal stability of fuels. Consideration is also given to sediments in fuel system components, self-ignition of fuels and explosion danger, the mutual effect of fuels and sealer materials, and methods for the protection of fuel systems against the effect of high temperatures. V.L.

A87-36644
MOLECULAR-BEAM STUDY OF THE FORMATION AND PROPERTIES OF H2O CLUSTERS
A. A. VOSTRIKOV, D. IU. DUBOV, and M. R. PREDTECHENSKII (AN SSSR, Institut Teplofiziki, Novosibirsk, USSR) (Zhurnal Tekhnicheskoi Fiziki, vol. 56, July 1986, p. 1393-1395) Soviet Physics - Technical Physics (ISSN 0038-5662), vol. 31, July 1986, p. 821, 822. Translation. refs

The gasdynamic molecular-beam method is used to study water cluster formation in a jet from a sonic nozzle with a diameter equal to 1 mm. A new general relation is obtained for the values the of prechamber water-vapor pressure and temperature at which the transition to developed condensation occurs in the free jet. Data are presented on the change in the average water-cluster size during changes in the conditions in the source and in the process of cluster detection using the electron-impact ionization method. The present study reveals that H2O clusters fragment upon impact with the surface, forming positively and negatively charged particles. Polar fragmentation of atmospheric water clusters may be one mechanism behind aircraft electrification. K.K.

A87-36793
EFFECTS OF IMPACT LOADS ON CFRP STRUCTURES [AUSWIRKUNGEN VON SCHLAGBEANSPRUCHUNGEN AUF CFK-STRUKTUREN]
J. BAUER and J. WARNECKE (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 342-345. In German. refs
(DGLR PAPER 86-147)

The results of experimental and theoretical studies of the basic mechanisms and physical laws governing the behavior of CFRP structures impacted by foreign bodies are reviewed. The types and extent of damage inflicted on the structures are examined along with the impact resistances of the different types of CFRP materials. Comparisons are made between the impact performances of metallic and CFRP structures. C.D.

A87-36797
USE OF FIBER COMPOSITE STRUCTURES IN THE AIRBUS PROGRAM [EINSATZ VON FASERVERBUNDSTRUKTUREN IM AIRBUS-PROGRAMM]
H. J. RIECKHOF (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 393-398. In German.
(DGLR PAPER 86-145)

The production steps involved in the construction of the carbon fiber composite middle body of the Airbus A300/A310 and the A320 are described. The technologies used in each of the steps are mentioned, and diagrams or photographs of each step are presented. Related future projects using fiber composite materials are briefly addressed. C.D.

A87-36855
THE EFFECT OF THERMAL TREATMENT ON PROPERTIES OF RAPIDLY SOLIDIFIED AA2024
L. KATGERMAN (Alcan International, Ltd., Banbury Laboratories, England) and B. VAN DEN BRANDT (Schweizerisches Institut fuer Nuklearforschung, Villigen, Switzerland) IN: High strength powder metallurgy aluminum alloys II; Proceedings of the Symposium on Aluminum Powder Metallurgy, Toronto, Canada, Oct. 13-17, 1985 . Warrendale, PA, Metallurgical Society, Inc., 1986, p. 65-78. Research supported by the Ministerie van Economische Zaken of the Netherlands. refs

The effect of ageing on the microstructure and tensile properties of rapidly solidified AA2024 was investigated. Because of the very fine grain size in r.s. aluminum alloys in general no improved tensile properties on artificial ageing are obtained. By a modified precipitation treatment grain boundary precipitation could be minimized and improved tensile properties were found. The modified thermal treatment was studied by transmission electron microscopy and differential scanning calorimetry. This investigation shows clearly that standard thermomechanical treatments originally developed for conventional alloys do not give optimum results when applied to rapidly solidified alloys. Author

A87-36866
ELEVATED TEMPERATURE MECHANICAL BEHAVIOR OF P/M DISPERSION STRENGTHENED AL-FE-NI ALLOYS
M. K. PREMKUMAR, M. J. KOCZAK, and A. LAWLEY (Drexel University, Philadelphia, PA) IN: High strength powder metallurgy aluminum alloys II; Proceedings of the Symposium on Aluminum Powder Metallurgy, Toronto, Canada, Oct. 13-17, 1985 . Warrendale, PA, Metallurgical Society, Inc., 1986, p. 265-284. USAF-supported research. refs

Elevated temperature tensile and creep properties of powder metallurgy Al-Fe-Ni alloys with FeNiAl9 dispersoid volume fractions of 0.19, 0.25, and 0.32 have been determined. Tests were conducted at temperatures up to 400 C. Ambient temperature strengthening can be explained by the Orowan dislocation bowing model. Yield strength decreases with increasing temperature and

above 300 C, it is independent of dispersoid size and dispersoid volume fraction. Steady state creep rate is independent of the dispersoid volume fraction over the temperature range 250 C - 400 C, and the average stress exponent is 10 with a creep activation energy of 76 kcal/mole. Elevated temperature deformation is consistent with a cooperative dislocation climb mechanism which is insensitive to dispersoid size and dispersoid volume fraction. Author

A87-38602*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
SEMI-INTERPENETRATING NETWORKS OF LARC-TPI
ANNEMARIE H. EGLI, LINDA L. KING, and TERRY L. SAINT CLAIR (NASA, Langley Research Center, Hampton, VA) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 440-453. refs

In a previous research project at NASA-Langley, a novel semi-2-interpenetrating polymer network (semi-2-IPN) was prepared from the linear, thermoplastic polyimidesulfone, and the more brittle, crosslinked, acetylene-terminated imidesulfone. Synergistic qualities such as improved thermooxidative stability and better processability were achieved from this combination. The novelty of the system lay in the fact that the structures of the linear and crosslinking components were nearly identical. This similarity in structure eliminates any phase separation problems common to many-IPNs. In a similar way, a semi-2-IPN was prepared from linear, thermoplastic LARC-TPI and acetylene-terminated LARC-TPI (ATLARC-TPI). The preparation and characterization of this system will be discussed as well as adhesive and composite data. Author

A87-38616#
THE ART OF RETICULATION AND APPLICABLE ADHESIVES
SID QUICK (Dexter Specialty Chemicals Group, Hysol Aerospace and Industrial Products Div., Pittsburg, CA) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 649-659.

The properties of the reticulatable adhesive film used in the development of acoustically-treated engine nacelles, and the equipment and procedures employed in the production of a specific adhesive film reticulating system, are discussed. An industrial reticulator is described which maintains consistent air temperature, air velocity, and adhesive exposure time to ensure continuous, uniform and reproducble fillets. Specifications require a 149-deg flatwise tensile value of 2.93 N/sq mm using a 9.52-mm cell size core, after 6K hours of 149-deg exposure. It is determined that the optimum blend of structural and acoustical properties are achievable only in the narrow adhesive flow range of 1.27 cm during the heat rise to 177 C, and the required flow rate control is accomplished by prebatching. R.R.

A87-38617#
THE EFFECT OF MULTIPLE ELEVATED TEMPERATURE BONDING CYCLES ON AS/3501-6 MECHANICAL PROPERTIES
W. J. MARTIN (Northrop Corp., Hawthorne, CA) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 660-669.

The effect of multiple thermal cycles on the mechanical properties of a moisture-conditioned parent gr/ep laminate simulating an in-service composite component is investigated. Mechanical property tests conducted on this laminate before and after simulated adhesive bonding repair cure cycles indicate thermal cycling sensitivity. The equilibrium moisture level of the parent matrix was found to increase from 1.6-1.9 percent after seven thermal cycles, and the amount of moisture lost during thermal cycling was shown to decrease with each successive thermal cycle. Results suggest that the mechanism by which moisture is retained within an epoxy matrix changes with repeated thermal cycles. R.R.

A87-39100#
COMPETING FACTORS IN THE AGING OF OIL IN PISTON AND GAS-TURBINE ENGINES [KONKURIRUIUSHCHIE FAKTORY V PROTSESSE STARENIIA MASLA V PORSHNEVYKH I GAZOTURBINNYKH DVIGATELIAKH]
S. V. VENTSEL', V. A. BAZDERKIN, and V. N. MAMAEV Khimiia i Tekhnologiia Topliv i Masel (ISSN 0023-1169), no. 3, 1987, p. 21-24. In Russian. refs

The effect of oil aging mechanisms on the wear-resistant properties of oil are investigated experimentally in the laboratory using a roller-roller friction machine at a maximum contact pressure of 514 MPa. Results are presented for specimens of 45 and ShKh15 steels (HRC 61-62) tested in used and fresh gas-turbine oils. The microhardness of the friction surfaces of rollers tested in an oil drained from a gas-turbine engine after the completion of the specified service period is found to be 6-25 percent higher than that of rollers tested in fresh oil. The competing factors involved in the aging of oils are identified which, on the one hand, are responsible for an improvement in wear-resistant and thermal stability characteristics of oils and, on the other hand, lead to a deterioration of oil performance. V.L.

N87-22052# National Aerospace Lab., Tokyo (Japan).
TENSILE STRENGTH OF ENGINEERING CERAMICS
YOSHIAKI FUJISAWA, KATSUTOSHI MATUSUE, and KITAO TAKAHARA 1986 11 p In JAPANESE; ENGLISH summary (NAL-TR-900; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

Uniaxial tensile strength tests of engineering ceramics were carried out in air at temperatures ranging from room temperature up to 1600 C. The ceramic materials chosen for tensile tests were selected as representing existing and developing silicon nitride, silicon carbide and partially stabilized zirconia materials technology, suitable for gas turbine applications. The tensile strength of silicon nitride rapidly decreased at temperatures above 800 to approx. 1000 C. When the temperature increased to as high as 1300 C, the strength decreased to about 10 percent of room temperature strength. On the other hand, the strength of silicon carbide did not change appreciably with temperature. The strength of zirconia decreased with increasing temperatures. At 1000 C the strength was reduced to 8 percent of room temperature strength. Observations of the fracture origin and of the crack propagation on the fracture surfaces are discussed. Author

N87-22054# Illinois Univ., Urbana. Dept. of Mechanical and Industrial Engineering.
EVAPORATION OF MONODISPERSE FUEL SPRAYS IN FLOWING AIR Final Report, 1 Feb. 1983 - 1 Dec. 1986
J. E. PETERS, H. KRIER, K. KIM, J. E. KIRWAN, and G. N. SCHROERING Dec. 1986 84 p
(Contract F49620-83-K-0027)
(AD-A177119; UILU-ENG-86-4012; AFOSR-87-0171TR) Avail: NTIS HC A05/MF A01 CSCL 21D

This is the Final Report of a research program dealing with liquid fuel droplet evaporation in flowing high temperature and pressurized air. A major effort was applied to the design, fabrication, and utilization of a heated air flow tunnel into which monodisperse droplets with controlled axial spacing and velocity. It was possible by photomicroscopy to measure the droplets (typically 100 microns) along individual spray streams, and then to calculate an effective evaporation rate. Both n-heptane and JP-4 fuels were injected into a hot air stream with air velocities typically exceeding 5 m/sec. The droplet evaporation data show that, for our spray, the quasi-steady isolated drop theory underestimates the evaporation rate. Air velocity and turbulence were measured by an LDV system and the recirculation zone downstream of the injector was precisely measured under cold and hot flow. These data, with the measured droplet evaporation, were sufficient in scope to allow a comparison of measurements with a comprehensive turbulent flow model. Results of that modeling work are presented and indicate that there is excellent agreement between analysis and measured flow conditions. GRA

N87-22808# National Research Council of Canada, Ottawa (Ontario). Div. of Mechanical Engineering.
ARTIFICIAL COMPOSITES FOR HIGH TEMPERATURE APPLICATIONS: A REVIEW
M. U. ISLAM, W. WALLACE, and A. Y. KANDEIL (Qatar Univ., Doha.) Jan. 1987 84 p
(DME-007; NRC-27323) Avail: NTIS HC A05/MF A01

A review is provided of developments in artificial, metal and ceramic matrix composites with potential for high temperature applications such as in the hot sections of gas turbine engines. Emphasis is placed on developments which have occurred since 1975. An attempt is made to assess the current level of activity and to identify outstanding problems and research directions for the future. To provide a basis for these discussions, the status prior to 1975 is also briefly reviewed. Author

N87-22811*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FIBER REINFORCED SUPERALLOYS
DONALD W. PETRASEK, ROBERT A. SIGNORELLI, THOMAS CAULFIELD, and JOHN K. TIEN (Columbia Univ., New York.) Apr. 1987 62 p
(NASA-TM-89865; E-3533; NAS 1.15:89865) Avail: NTIS HC A04/MF A01 CSCL 11D

Improved performance of heat engines is largely dependent upon maximum cycle temperatures. Tungsten fiber reinforced superalloys (TFRS) are the first of a family of high temperature composites that offer the potential for significantly raising hot component operating temperatures and thus leading to improved heat engine performance. This status review of TFRS research emphasizes the promising property data developed to date, the status of TFRS composite airfoil fabrication technology, and the areas requiring more attention to assure their applicability to hot section components of aircraft gas turbine engines. Author

N87-22858# Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Engineering Mechanics.
EROSION STUDY OF AM355 AND AL2O3 CERAMICS
W. TABAKOFF, A. HAMED, and S. Y. KANG 15 Jan. 1987 94 p
(Contract DAAG29-82-K-0029)
(AD-A178882; REPT-87-58; ARO-18560.30-EG) Avail: NTIS HC A05/MF A01 CSCL 11F

The need for the knowledge and better understanding of material erosion behavior is necessary for the confident use of these materials in future helicopter engines. This investigation presents a detailed study of the erosion behavior of a typical ductile material (steel AM355 alloy) and a nonductile (brittle) material (aluminum oxide). The experimental results show the influence of particle size, particle velocity and temperature on the erosion rate. Electron micrographs of the eroded surfaces under various conditions are presented and compared. Empirical correlations for the erosion results are also presented. GRA

N87-22864# Federal Aviation Agency, Atlantic City, N.J. Technical Center.
LABORATORY CHARACTERIZATION TESTS FOR ANTIMISTING FUEL Final Report
JOSEPH WILSON Mar. 1987 131 p
(DOT/FAA/CT-86/23) Avail: NTIS HC A07/MF A01

Experiments have shown that FM-9 antimisting fuel has the potential for precluding the fine mist and associated fireball generation in aircraft postcrash situations while allowing for the restoration of the filtration and atomizing characteristics required for aircraft operation. Many specialized laboratory characterization tests were developed to evaluate the antimisting properties, the degradability, the composition, and rheological properties of FM-9 antimisting fuel and the physical properties of FM-9 slurry used in the inline blending process for antimisting fuel. All the laboratory characterization tests that were successfully developed and used as a standardized test method are documented. A literature search was done, and a detailed review and analysis of each test method was conducted. This led to the following information: background on the intent and operation of the test method and theory behind the rheological property that the test method is evaluating relative to antimisting fuel; description of the test apparatus along with a general overview of the operational procedure of the test method; equipment specifications for the test apparatus; an accurate and detailed procedure for the test method; and an interpretation of the test results and a discussion of the effectiveness, repeatability, applications, and limitations of the test method. Author

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ENGINEERING

Includes engineering (general); communications and radar; electronics and electrical engineering; mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A87-35286
PROBABILISTIC FRACTURE MECHANICS AND RELIABILITY
JAMES W. PROVAN, ED. (McGill University, Montreal, Canada) Dordrecht, Martinus Nijhoff Publishers (Engineering Application of Fracture Mechanics. Volume 6), 1987, 482 p. For individual items see A87-35287 to A87-35292.

Papers are presented on probabilistic approaches to the material-related reliability of fracture-sensitive structures, probabilistic damage tolerance analysis of aircraft, aircraft structural reliability and risk analysis, stochastic-crack growth models for applications to aircraft structures, and the durability of aircraft structures. Consideration is also given to the reliability of pressurized water reactor vessels; applications of probabilistic fracture mechanics (PFM) in the nuclear industry to the reactor pressure vessel, main coolant piping, and steel containment; and numerical methods in PFM. Finally, an overview is given of PFM with attention focused on its statistical basis, engineering models, and application examples. K.K.

A87-35288
PROBABILISTIC DAMAGE TOLERANCE ANALYIS OF AIRCRAFT STRUCTURES
B. PALMBERG, A. F. BLOM, and S. EGGWERTZ (Flygteknsika Forsoksanstalten, Bromma, Sweden) IN: Probabilistic fracture mechanics and reliability . Dordrecht, Martinus Nijhoff Publishers, 1987, p. 47-130.

A probabilistic damage tolerance analysis of aircraft structures is carried out with attention given to metal airframe structures and wing panels. A model is presented with accounts for the stochastic variation of the load history, the size of the initial defects, the crack growth rate, and the residual strength deteriorating with time. The effect of inspections is considered on the basis of information on the probability of crack detection as a function of crack size. USAF damage tolerance requirements are discussed. K.K.

A87-35289
AIRCRAFT STRUCTURAL RELIABILITY AND RISK ANALYSIS
F. H. HOOKE IN: Probabilistic fracture mechanics and reliability . Dordrecht, Martinus Nijhoff Publishers, 1987, p. 131-170.

Basic reliability and risk mathematics are considered as well as the physical aspects of structural failure. A mathematical-statistical model representing a real structural situation is presented. The safe life situation of reliability without inspections is discussed with attention given to the risk of static ultimate load failure, the risk of failure with deteriorating strength, structures with initial cracks, and structures with multiple failure modes and locations. The risk of failure of inspectable structures is also examined. Illustrative examples are provided which include a safe life situation (an ultrahigh-strength material) and a safety-by-inspection situation (typical aluminum alloy material). The reliability of reliability estimates is assessed. K.K.

A87-35290
STOCHASTIC CRACK GROWTH MODELS FOR APPLICATIONS TO AIRCRAFT STRUCTURES
J. N. YANG, W. H. HSI (George Washington University, Washington, DC), S. D. MANNING (General Dynamics Corp., Fort Worth, TX), and J. L. RUDD (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Probabilistic fracture mechanics and reliability . Dordrecht, Martinus Nijhoff Publishers, 1987, p. 171-211.
(Contract F33615-83-K-3226)
The validity and practicality of lognormal crack growth rate models are examined on the basis of fatigue growth data of fastener hole specimens. New stochastic models using the second moment approximation approach are proposed and verified. Fatigue crack propagation in center-cracked specimens is investigated and comparisons are made with experimental test results. In addition, consideration is given to factors affecting the accuracy of stochastic crack propagation analysis such as the data processing procedures for obtaining crack growth rate data and the number of fractographic readings for each specimen. K.K.

A87-35291
DURABILITY OF AIRCRAFT STRUCTURES
S. D. MANNING (General Dynamics Corp., Fort Worth, TX), J. N. YANG (George Washington University, Washington, DC), and J. L. RUDD (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Probabilistic fracture mechanics and reliability . Dordrecht, Martinus Nijhoff Publishers, 1987, p. 213-267.
A durability analysis methodology which is based on a probabilistic fracture mechanics approach is presented. A characteristic feature of this methodology is the analytical representation of the initial fatigue quality of the structure which is represented statistically by a distribution of equivalent initial flaw sizes. The accuracy of the analysis is evaluated by correlating analytical predictions with test data for a fighter full-scale test article and complex splice specimens subjected to a bomber load spectrum. The benefits of this probabilistic approach over a currently existing deterministic approach are discussed. K.K.

A87-35300
QUANTITATIVE VISUALIZATION OF STEADY AND UNSTEADY FLOWS USING SPARK VELOCIMETRY
E. C. HANSEN (Florida, University, Gainesville) Review of Scientific Instruments (ISSN 0034-6748), vol. 58, March 1987, p. 444-450. Research supported by the United Technologies Corp. refs
This paper describes the usefulness, limitations, and potential applications of spark velocimetry to complex flows in fluid machinery. Spark velocimetry uses high-voltage high-frequency sparks to successively illuminate a column of air particles and thus map out a complex velocity field. This work applied spark velocimetry to a two-dimensional boundary layer, a three-dimensional horseshoe vortex boundary layer, and boundary layers on the suction surface of a rotor blade in steady flow and in rotating stall. Measurements made in a two-dimensional boundary layer compared favorably with measurements taken using a total pressure probe. The measurements in the horseshoe vortex showed the types of primary and secondary flow expected. The velocity profile of the boundary layer on a rotor blade was shown in both unstalled and stalled flow. The spark velocimetry method was shown to be a very useful measurement tool for three-dimensional and unsteady flows with some limitations. Author

A87-35395
CUTTING AEROSPACE STRUCTURES WITH WATER
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 7, March 1987, p. 4-9.
A system that combines water jet cutting equipment with a six-axis gantry robot capable of cutting and trimming highly contoured shapes is proposed. The robotic abrasive water jet cutter system is composed of a PC/AT cell controller computer, a six-axis gantry robot, and a 60 hp dual intensifier pump. The features of the robot, and the operation of the system are described. The use of an energy absorption system, which functions to dissipate the kinetic energy of the water jet, for the cutting of stiffened panels is examined. The various fixtures and sensors used in conjunction with the cutter system are considered. The need for numerical control programs for each part of the system is discussed. I.F.

A87-35397
TOWARD THE FACTORY OF THE FUTURE
JAMES H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 7, March 1987, p. 34-38.
The use of automation and computer technology to improve the manufacturing processes in the aerospace industry is examined. Research applying microelectronics, AI, and process science to the manufacturing of aerospace parts is discussed. The development and functions of a flexible machining system that is to improve quality and reduce costs are described. I.F.

A87-35655#
FATIGUE CRACK PROPAGATION UNDER SPECTRUM LOADING
R. SUNDER (National Aeronautical Laboratory, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Aug. 1986, p. 153-160. Research supported by the Aeronautical Research Development Board. refs
This project involved the development of a method to predict the fatigue crack propagation process in thin-walled aircraft structural components under flight-by-flight loading. Extensive experimental test results provided the input for software development. They yielded evidence pointing to the complex nature of crack growth under spectrum loading and also provided the basis for procedures adopted for life prediction. A simple engineering method is proposed for estimating fatigue crack propagation life under random loading. Predictions are based on test data obtained under constant amplitude loading. Prediction accuracy favorably compares with that of available techniques. Computation time is extremely small, enabling the use of desktop computers for life predictions. Author

A87-35657#
NON-LINEAR EQUATION OF MOTION OF FIBRE REINFORCED COMPOSITE ROTOR BLADES
K. MANJUNATHA UDUPA and V. T. NAGARAJ (Hindustan Aeronautics, Ltd., Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Aug. 1986, p. 173-180. refs
The nonlinear equations of motion for fiber-reinforced plastic blades with a C-spar are derived using a Newtonian technique. Particular emphasis is given to the structural behavior of the fiber-reinforced plastic blades compared to the behavior of metal blades. Strain-displacement and stress-strain relations, and section force and moment resultants are examined. I.F.

A87-35659#
VIBRATION CHARACTERISTICS OF NON-UNIFORM ROTOR BLADES WITH DISCONTINUITIES
N. SAHU and V. T. NAGARAJ (Hindustan Aeronautics, Ltd., Helicopter Design Bureau, Bangalore, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Aug. 1986, p. 189-195. refs
The Rayleigh-Ritz finite element method is utilized to estimate the vibration characteristics of rotating blades. The uncoupled flapwise and chordwise vibrations of the blades are examined. The equation for the vibrations are written in a nondimensional form as: (1) quintic element (6-0), (2) quintic element (6-1), (3) cubic element (4-0), and (4) septic element (8-0). The finite element method is applied to calculate the frequencies, mode shapes, bending moment, and shear force distributions of nonuniform blades with discontinuities in stiffness and mass. The results are compared with previous data obtained using different methods, and it is determined that the finite method provides accurate results. I.F.

A87-36290*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
WEIGHT ESTIMATION OF UNCONVENTIONAL STRUCTURES BY STRUCTURAL OPTIMIZATION
HIROKAZU MIURA (NASA, Ames Research Center, Moffett Field, CA) and ALBERT SHYU (FMC Corp., San Jose, CA) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 22 p. refs
(SAWE PAPER 1718)

Automated techniques are presented that are used in structural optimization technology, with emphasis on modifications of finite element models to obtain an optimal material distribution for minimum weight while satisfying the prescribed design requirements. It is anticipated that the future development of computer aided engineering (CAE) system will provide environments where structural analysis, a design optimization, and weight evaluation modules are integrated, sharing a common data base. Structural optimization capabilities obtained by integrating a finite element structural analysis program and a numerical optimization code are developed and applied to two illustrative examples: marine gear housing structural weight minimization and joined wing structures. D.H.

A87-36295
THE TEN DOLLAR LOAD CELL
HOWARD A. NIELSEN, JR. SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 12 p. refs
(SAWE PAPER 1724)

Inexpensive load cells for electronic weighing are considered, with attention being given to cost factors. Historically, such load cells have cost hundreds of dollars, but five low capacity cells are described with prices in the ten-dollar range. Consideration of the criteria necessary to achieve such low prices has permitted a useful outline to be drawn up showing load cell cost factors to get accurate weighing electronically. Performance specifications and physical characteristics of six different types of resistive strain gage are reviewed, and reasons are given why the etched foil strain gage is the most common gage used in electronic weighing. Prospects for lower-cost high-capacity load cells are outlined. D.H.

A87-36303*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
THE PULTRUSION PROCESS FOR STRUCTURES ON ADVANCED AEROSPACE TRANSPORTATION SYSTEMS
MAYWOOD L. WILSON, IAN O. MACCONOCHIE, and GARY S. JOHNSON (NASA, Langley Research Center, Hampton, VA) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 12 p. refs
(SAWE PAPER 1741)

The pultrusion process, which has the potential for use in the manufacture of structures for aerospace hardware, is described. In this process, reinforcing fibers are pulled continuously through a resin system for wetting and subsequently through a heated die for polymerization. By using this process, fabrication of very long lengths of high strength, lightweight structures with consistently high quality for aerospace applications is possible. The more conventional processes involve hand lay-up, vacuum bagging, autoclaving or oven curing techniques such that lengths of structural elements produced are limited by the lengths of autoclaves or curing ovens. Several types of developmental structural elements are described in which fiberglass, aramid, graphite, and hybrid fiber systems have been used as reinforcements in an epoxy matrix and their flexural properties compared. Reinforcement fibers having tailor-made orientations which achieve tailor-made strength in the pultrusions are described. The potential aerospace applications for the pultruded products are described with advantages cited over conventional hand lay-up methods. Author

A87-36796
ASPECTS OF FUTURE CIM SOLUTIONS [ASPEKTE ZUKUENFTIGER CIM-LOESUNGEN]
WERNER FISCHER (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 368-371. In German.
(DGLR PAPER 86-169)

Due to the complexity of the data quality and quantity used in CAD/CAM systems, integrated CIM (computer-integrated manufacturing) with suitable data banks is required. Suggestions and studies in progress on modern interfaces and hardware satisfying these requirements are discussed, including user aspects such as 'open' CAD/CAM systems, localized-centralized workstations, and data management. The state of the art with regard to internationally cooperative aircraft construction is considered along with trends and future developments. C.D.

A87-36885
SOLVING STRUCTURAL TEST PROBLEMS WITH PHOTOELASTIC COATINGS
T. W. CORBY (Measurements Group, Inc., Raleigh, NC) and S. REDNER (Strainoptic Technologies, Inc., Norristown, PA) IN: International Conference on Experimental Mechanics, Beijing, People's Republic of China, Oct. 7-10, 1985, Proceedings . Beijing, Science Press, 1985, p. 247-254.

The principles of the photoelastic coating technique of stress analysis are discussed together with a select group of case history examples to illustrate the effectiveness of the method in analyzing special classes of stress problems. These cases include stresses due to the mechanical assembly of the component parts of a structure; residual stress that can be caused by manufacturing processes; working stresses caused by very complex service conditions; and stresses caused by unexpected material defects in a structure. In addition, consideration is given to the analysis of the stresses in composite materials where accurate simulation of the material behavior under load is exceedingly difficult to model, and to the detection of local yielding where analytical methods cannot infallibly predict its occurrence. I.S.

A87-36898
ON THE NATURAL VIBRATION OF THE AIRCRAFT STRUCTURAL MODEL
TAKETOSHI HANAWA and KEIJI KOMATSU (National Aerospace Laboratory, Chofu, Japan) IN: International Conference on Experimental Mechanics, Beijing, People's Republic of China, Oct. 7-10, 1985, Proceedings . Beijing, Science Press, 1985, p. 668-673.

A summary of experience acquired in experimental vibration testing of a structural model is presented. The model was accelerated by sine swept forces from electromagnetic shakers, and the deflection responses of the model were compared with the forces. Then, the resonance frequencies were determined from this response-force Lissajous figure. At these resonances, sand was spread over the horizontally suspended model to detect the nodal lines and to measure the deflection responses at many points to get the natural modes. It is concluded that such experiments, together with the analysis of Hanawa and Komatsu (1974, 1980), can be used to roughly estimate the characteristics of such a structure at the beginning of the design phase. Author

A87-37040
ON THE HEAT TRANSFER CHARACTERISTICS OF CONSTRAINED AIR JETS IMPINGING ON A FLAT SURFACE
M. SHOUKRI and A. CALKA (McMaster University, Hamilton, Canada) International Journal of Heat and Mass Transfer (ISSN 0017-9310), vol. 30, Jan. 1987, p. 203-205. refs

An experimental investigation of the heat transfer properties of constrained air jets impinging on a flat surface indicates that the heat transfer coefficients increased with increasing jet Reynolds number and decreasing (1) heat transfer surface radius and (2) distance between surface and nozzle exit. These data are

successfully correlated by means of an empirical equation. Except for low radius/diameter values, constrained impinging jets are found to be less capable of removing heat from flat surfaces than free, unconstrained impinging jets under similar conditions; this can be explained in terms of the resulting flow field in each case. O.C.

A87-37116#
EFFECT OF POROSITY STRENGTH ON PASSIVE SHOCK-WAVE/BOUNDARY-LAYER CONTROL
S. RAGHUNATHAN (Belfast, Queen's University, Northern Ireland) AIAA Journal (ISSN 0001-1452), vol. 25, May 1987, p. 757, 758. SERC-supported research.

A porous surface with a plenum chamber under the shock location is an economical means for the reduction of transonic speed drag; the porous surface may be formed by normal or inclined holes, or slots. Attention is presently given to the performance of inclined holes. Four models were tested for Mach numbers of 1.3 and 1.37. A surface porosity of 1-2 percent is found to yield maximum drag reduction. O.C.

A87-37208*# Indian Inst. of Tech., Madras.
PERFORMANCE STUDIES ON AN AXIAL FLOW COMPRESSOR STAGE
N. SITARAM (Indian Institute of Technology, Madras, India) Aeronautical Society of India, Journal (ISSN 0001-9267), vol. 38, Nov.-Dec. 1986, p. 267-275. refs
(Contract NSG-3032)

A low-speed, medium loaded axial flow compressor stage is studied experimentally and theoretically. The flow compressor facility, composed of an inlet guide vane row, a rotor blade row, and a stator blade row, and the principles of the streamline curvature method (SCM) and the Douglas-Neumann cascade program are described. The radial distribution of the flow properties, the rotor blade static pressure distribution, and the lift coefficient and relative flow angle derived experimentally and theoretically are compared. It is determined that there is good correlation between the experimental flow properties and the SCM data, the Douglas-Neumann cascade program and experimental rotor blade static pressure data, and the experimental and theoretical lift coefficients only in the midspan region. Modifications to the SCM and the Douglas-Neumann cascade program in order to improve their accuracy are discussed. I.F.

A87-37215
A MUTUALLY PROFITABLE ALLIANCE - ASYMPTOTIC EXPANSIONS AND NUMERICAL COMPUTATIONS
D. EUVRARD (Ecole Nationale Superieure de Techniques Avancees, Palaiseau, France) Journal de Mecanique Theorique et Appliquee Supplement (ISSN 0750-7240), 1986, p. 25-45. refs

Problems including the flow past a wing airfoil at Mach 1, and the two-dimensional flow past a partially immersed body are used to show the advantages of coupling a standard numerical method for the whole domain where everything is of the order of 1, with an appropriate asymptotic expansion in the vicinity of some singular point. Cases more closely linking the two approaches are then considered. In the localized finite element method, the asymptotic expansion at infinity becomes a convergent series and the problem reduces to a variational form. Combined analytical and numerical methods are used in the singularity distribution method and in the various couplings of finite elements and a Green integral representation to design a subroutine to compute the Green function and its derivatives. R.R.

A87-37216
MODELLING OF SEPARATING FLOW AND ITS STABILITY
F. T. SMITH (University College, London, England) Journal de Mecanique Theorique et Appliquee Supplement (ISSN 0750-7240), 1986, p. 47-71. refs

Recent developments in the asymptotic modelling of separated flows and their stability are reviewed, with application to aeromachinery and turbomachinery dynamics, physiological flows and geophysical fluid dynamics. Aerodynamic and related motions are discussed, with consideration given to attached flow and breakdown, large and small scale separated flow and their stability, and three-dimensional flows. The discussion of internal flows includes nonsymmetric channel flows and three-dimensional pipe motions and their stability with separation occurring. Liquid layers, separation and hydraulic jumps are also considered. The related area of transition modelling is also briefly discussed. R.R.

A87-37428#
DATA ACQUISITION TECHNIQUES USED FOR MIL-STD-1553 DATA
MARK R. CELLARIUS and DAVID PENHARLOW (Aydin Corp., Aydin Vector Div., Newtown, PA) IN: ITC/USA/ '86; Proceedings of the International Telemetering Conference, Las Vegas, NV, Oct. 13-16, 1986 . Research Triangle Park, NC, Instrument Society of America, 1986, p. 665-672.

This paper will address various applications and methods used for the acquisition, recording, and telemetering of data from the MIL-STD-1553 avionic multiplexer data bus installations in aircraft, missiles, and other vehicles. Discussions of the problems encountered and hardware utilized in current applications are reviewed. The innovative techniques used to optimize system performance, and future trends for program requirements are also discussed. Author

A87-37848#
HEAT TRANSFER THROUGH MULTI-TURNS OF COOLING PASSAGES IN A TURBINE BLADE
YUMIN ZHANG, WEIZAO GU, and JIARUI SHEN (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of Journal of Aerospace Power, vol. 2, Jan. 1987, p. 78-80, 95, 96. In Chinese, with abstract in English.

With the aim of cooling a high-temperature turbine blade, the heat transfer characteristics and flow drag of turbulent air flow through 180 degree multiturns of rectangular passages were investigated experimentally. The experimental data of the heat transfer coefficients both through a 180 degree turn and in a straight passage were correlated. The test results may be useful to cooling designing gas turbine blades. Author

A87-38037#
SUPERSONIC BOUNDARY LAYER WITH OR WITHOUT AN INTERACTION SHOCK - COMPARISON BETWEEN HOT-WIRE ANEMOMETRY AND LASER VELOCIMETRY [COUCHE LIMITE SUPERSONIQUE AVEC OU SANS CHOC D'INTERACTION - COMPARAISON ENTRE ANEMOMETRIE A FIL CHAUD ET VELOCIMETRIE A LASER]
M. ELENA and J. P. LACHARME (CNRS; Aix-Marseille II, Universite, Marseille, France) Association Aeronautique et Astronautique de France, Colloque d'Aerodynamique Appliquee, 23rd, Modane, France, Nov. 12-14, 1986. 19 p. In French. DRET-ONERA-supported research. refs
(AAAF PAPER NT 86-14)

Results obtained in a supersonic wind tunnel by hot-wire anemometry and laser velocimetry are compared for the case of an incompressible turbulent boundary layer in quasi-equilibrium and for the interaction of this boundary layer with an oblique shock wave. The freestream Mach number is 2.32, and a 6-deg deflection is imposed on the turbulent boundary layer by the shock wave. Good agreement is found between turbulence-intensity results obtained by the two methods, except in the internal region of the boundary layer. It is suggested that values obtained by laser anemometry for distributions of the Reynolds shear stress are more reliable than those obtained by hot-wire anemometry, except in the internal region of the boundary layer. R.R.

A87-38461#
EXPERIMENTAL OBSERVATION OF CAVITATING SQUEEZE-FILM DAMPERS
J. F. WALTON, II, J. A. WALOWIT, E. S. ZORZI (Mechanical Technology, Inc., Latham, NY), and J. SCHRAND (USAF, Wright-Patterson AFB, OH) ASME, Transactions, Journal of Tribology (ISSN 0742-4787), vol. 109, April 1987, p. 290-294; Discussion, p. 294, 295. refs
(Contract F33615-79-C-2050)

High-speed photographs and stroboscopic video recordings of cavitating squeeze-film bearing dampers were obtained using two different squeeze-film damper geometries commonly found in aircraft gas turbine engines. The dampers were installed in a specially designed test rig and photographed at speeds up to 20,000 rpm. Both end-groove and hole-fed dampers were tested, varying the oil supply pressure, damper eccentricity, and oil viscosity parameters during the tests. The experimental results were compared with the predictions made by the analysis formulated to handle the dynamics of the film rupture zone for a 'short' damper case. Several of the theoretical assumptions (i.e., the predominant axial flow and the effect of the supply pressure and eccentricity on the cavitation zone) were confirmed by the test results. However, the analysis did not adequately account for the observed variations in the boundaries and change in the shape of the cavitation zone. I.S.

A87-38545#
QUANTITATIVE FRACTOGRAPHIC EXAMINATION OF AIRCRAFT COMPONENTS TESTED UNDER A FATIGUE SPECTRUM LOADING
E. ABRAMOVICI, M. BURAK, K. C. OVERBURY, and D. R. TURNER (Canadair, Ltd., Montreal, Canada) IN: Strength of metals and alloys; Proceedings of the Seventh International Conference, Montreal, Canada, Aug. 12-16, 1985. Volume 2 . Oxford, Pergamon Press, 1986, p. 1355-1360.

The objectives and techniques of fractographic examination as a part of an aircraft certification program were described. The safe life of a main landing gear lug fabricated from a high strength aluminum alloy forging was then estimated based on the results of quantitative fractographic examination. Author

A87-38555#
ANALYSIS OF ELASTIC AND PLASTIC DEFORMATION IN A LAYERED STRUCTURE SUBJECTED TO ROLLING-SLIDING CONTACT
N. TUNCA and E. E. LAUFER (Nova Scotia, Technical University, Halifax, Canada) IN: Strength of metals and alloys; Proceedings of the Seventh International Conference, Montreal, Canada, Aug. 12-16, 1985. Volume 2 . Oxford, Pergamon Press, 1986, p. 1557-1562. refs

A layered structure has been observed to develop on rollers in a high speed roller bearing, operated under conditions of insufficient lubrication. This consists of a hard outer layer (1150 HK), going abruptly to a soft layer (600 HK) and shading gradually to the normal material (750 HK). Finite element studies have been done on this system to study the effects of this layered structure on cyclic crack propagation. The results of these studies are compared with studies on homogeneous material, and with experimental observations. Author

A87-38591#
IONIC CLEANING AFTER WAVE SOLDER AND BEFORE CONFORMAL COAT
TOCHAU N. NGUYGEN and THOMAS H. SUTHERLAND (Hughes Aircraft Co., Missile Systems Group, Tucson, AZ) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 297-308. refs

An account is given of efforts made by a military electronics manufacturer to upgrade product reliability in response to the printed writing board (PWB) ionic cleanliness requirements recently set out in MIL-P-28809 Rev. A. These requirements had to be met both after wave soldering, involving the immediate removal of ionically active RA flux, and immediately before conformal coating, in order to remove the less active RMA flux and bonding contaminants. Attention is given to the results of a test program which compared the effectiveness with which five different solvents and two (batch and conveyorized vapor degreasing) cleaning methods cleaned representative PWBs containing many components. Alcohol-containing fluorocarbon blends were adequate, but the most densely packed PWBs required a supplemental water rinse. O.C.

A87-38595#
STRESS ANALYSIS OF A ROTATING COMPOSITE DISK CONTAINING HOLES
CHUNG-LIN WU and TIN-YEW YE (Industrial Technology Research Institute, Hsin-chu, Republic of China) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 350-359.

The finite element method is applied to calculate the inplane stress distribution in a rotating composite disk which has a series of round or elliptical holes. Eight-node isoparametric elements are used to idealize the composite disk under study. Plane stress conditions of linear elasticity are used. It is concluded that the peak stress distribution around the holes is significantly affected by the laminating stacking sequence and geometrical parameters (i.e., hole size, hole shape and hole number). The stress concentration in a disk with six hole is less than that with four holes for the same size of cutouts. Author

A87-38630#
THE EVALUATION OF SURFACE TREATMENT FOR BOND DURABILITY
WEN-YUNG SHU and CHING-LONG ONG (Aero Industry Developing Centre, Taichung, Republic of China) IN: International SAMPE Technical Conference, 18th, Seattle, WA, Oct. 7-9, 1986, Proceedings . Covina, CA, Society for the Advancement of Material and Process Engineering, 1986, p. 888-897. refs

Three pretreatment procedures, the FPL etch, phosphoric acid anodizing (PAA), and 20 and 40 volt chromic acid anodizing procedures (20V/40V CAA), are found to produce similar bond strength and durability. Wedge tests rank the surface treatment methods by decreasing bond durability in the order PAA, 20V/40V CAA, and FPL. Primer applied before the bonding operations was found to increase the surface bond durability. R.R.

A87-38707#
A TEMPERATURE SENSOR WITH IMPROVED PERFORMANCE AND RELIABILITY FOR USE AT LOW MACH NUMBER AND DENSITY
RON L. CLOUSE (Sverdrup Technology, Inc., Arnold Air Force Station, TN) and TIMOTHY LAM (Weed Instrument Co., Inc., Round Rock, TX) IN: Aerospace environmental systems; Proceedings of the Sixteenth Intersociety Conference on Environmental Systems, San Diego, CA, July 14-16, 1986 . Warrendale, PA, Society of Automotive Engineers, Inc., 1986, p. 51-56.
(SAE PAPER 860915)

The USAF's new Aeropropulsion System Test Facility (ASTF) will be dedicated to the testing of large jet engines under controlled flight conditions to yield highly accurate and reliable measurements of performance parameters, even in simulated hostile environments involving high gust loads and ice particles. Attention is presently given to the design characteristics and performance capabilities of temperature sensors for the ASTF that are compatible with control requirements; the high degree of coupling that exists among accuracy, response, and reliability requirements is emphasized. O.C.

A87-38788#
A DIFFERENTIAL APPROACH TO HEAT PIPE PRIMING IN MICROGRAVITY
G. P. PETERSON (Texas A & M University, College Station) and K. ANNAMALAI IN: Symposium on Microgravity Fluid Mechanics; Proceedings of the Winter Annual Meeting, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 25-29. refs

Presented here is a study of the forces governing the liquid and vapor flow, in an external artery heat pipe. A differential analysis was performed on the heat pipe based upon the continuity and momentum equations. Using these fundamental equations, a computer model was developed, capable of predicting the fluid motion resulting from the surface tension and viscous frictional forces in a microgravity environment. The model used a nested iterative technique to first establish the pressure distribution along the longitudinal axis of the heat pipe for a known displacement. Then the time necessary, for a given fluid to initially assume or return to original the configuration required for proper operation, was calculated. In addition to providing an estimate of the required priming time, the model predicted that priming could be prematurely terminated. Comparisons of the predicted priming time and priming limitations were made with the results of an experimental test package flown on the NASA KC-135 Zero-g aircraft. The results of this comparison helped to establish the accuracy of the modeling techniques. Author

A87-38821#
COMBINED ANALYTICAL/EXPERIMENTAL STRUCTURAL MODIFICATION USING IMPROVED COMPONENT MODE SYNTHESIS
YUNG-TSENG CHUNG (Bell Helicopter Textron, Inc., Fort Worth, TX) IN: Reanalysis of structural dynamic models; Proceedings of the Symposium, Anaheim, CA, Dec. 7-12, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 57-72. refs

A component mode synthesis which includes the coupling rotational coordinates and takes into account the effects of the residual flexibilities based on experimentally measured data is presented. The required rotational displacements at the component interface are determined from the measured translational mode shapes by cubic spline interpolation. Residual modes which result from static approximation of neglected higher modes are computed directly from existing modal parameters. A coupling method which employs measured incomplete normal modes in conjunction with the residual flexibilities to account for the contribution of the neglected higher order modes is derived. Numerical results indicates the coupling method developed provides system equations of motion with reduced number of degrees of freedom leading to more accurate approximations to the system frequencies than are obtained by pure mode truncation in the frequency range of interest. Author

A87-39175#
THEORY AND DESIGN OF TURBOCOMPRESSORS (2ND REVISED AND ENLARGED EDITION) [TEORIIA I RASCHET TURBOKOMPRESSOROV /2ND REVISED AND ENLARGED EDITION/]
KONSTANTIN PAVLOVICH SELEZNEV, IURII BORISOVICH GALERKIN, SERGEI ALEKSANDROVIC ANISIMOV, V. P. MITROFANOV, and IU. S. PODOBUEV Leningrad, Izdatel'stvo Mashinostroenie, 1986, 392 p. In Russian. refs

Problems related to the theory and design of turbocompressors are examined in the context of the gasdynamic theory of cascades. In particular, attention is given to the thermodynamic principles of turbomachine theory; fundamentals of gas dynamics; elements of wing theory; flow past plane, circular, annular, and three-dimensional cascades; and the design of turbocompressor stages. The discussion also includes the mathematical modeling of working processes in the flow path of turbocompressors. V.L.

N87-21889# Thomson-CSF, Meudon-la-Foret (France). SDC Div.
MONOPULSE SECONDARY RADAR: PRACTICAL REALIZATION AND ACHIEVEMENT. MODE S: THE RADAR OF TOMORROW
FRANCOIS DELILLE *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 15 p Dec. 1986
Avail: NTIS HC A15/MF A01

There can be no doubt that Mode S will be part of tomorrow's Air Traffic Control (ATC) radar. Its assets in terms of air traffic surveillance and data link are noted. Fundamental characteristics are its comptatibility with existing secondary surveillance radar's (SSR), selective interrogation and monopulse reception. The monopulse SSR is a landmark in the transition towards Mode S; it contributes several major improvements, without requiring onboard transponders to be changed. Choices made in the implementation of the system are discussed, in particular as regards the antenna, transmitter, reception and processing techniques. Through these options, full Mode S compability is maintained. Practical results have turned out to be conclusive, and so the system was taken into production and already many stations are operational round the world. The Mode S extension which has to be added to the monopulse radar is also described, and it is being operated at Orly as part of an experimental development program. Author

N87-21890# Thomson-CSF, Meudon-la-Foret (France). SDC Div.
A PRACTICAL EXAMPLE OF MOVING TARGET DETECTION (MTD) PROCESSING FOR AN AIR TRAFFIC CONTROL RADAR WITH WEATHER CHANNEL
CHRISTINE BRUNO *In* AGARD Efficient Conduct of Individual Flights and Air Traffic or Optimum Utilization of Modern Technology for the Overall Benefit of Civil and Military Airspace Users 9 p Dec. 1986
Avail: NTIS HC A15/MF A01

Air Traffic Control (ATC) radar processing of the Moving Target Detector (MTD) type is described. It comprises an independent processing channel called weather channel, which supplies meteorological data. The MTD processing technique is aimed at improving the detection of useful targets in the midst of clutter. The algorithms employed are detailed, as well as the performance to be expected, in particular the improvement in the radar picture presented to the operator. The processing system is made up of programmable processors, of which the architecture and other main features are described, as is the radar station remote monitoring and maintenance system. Finally, results obtained in experiments are given. Author

N87-21939# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
NUMERICAL VISCOUS-INVISCID INTERACTION METHOD FOR INTERNAL SEPARATED FLOWS AND SHOCK WAVE-BOUNDARY LAYER INTERACTION
J. C. LEBALLEUR and D. BLAISE *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 20 p Mar. 1987 In FRENCH; ENGLISH summary
Avail: NTIS HC A16/MF A01

A calculation method for internal transonic separated flows, and for shock wave-boundary layer interactions, is presented. It is based on developments in indirect numerical solvers with viscous-inviscid splitting, well conditioned at high Reynolds numbers. The viscous flows are calculated with the defect formulation theory, here simplified with thin layers approximations compatible with an integral method. The direct and semi-inverse strong coupling methods, and the direct and inverse defect integral methods with turbulence models involving 0, 1, or 2 integral transport equations, which were previously suggested for airfoils flows, were generalized to internal flows for which the inviscid field requires the use of an Euler solver. Results are obtained for turbulent flows in transonic shocked channels with backpressure, involving multiple shock wave-boundary layer interactions, and

incipient or extensive separations. The method is also applied to supersonic shock wave-boundary layer interactions, for compression ramps or shock wave-reflexions. First results obtained for computing viscous flows in cascades are presented. Author

N87-21948# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
DETERMINATION OF THE SUPERSONIC CASCADE ENTRANCE ZONE [DETERMINATION DE LA REGION DE CAPATION D'UN GRILLE D'AUBES SUPERSONIQUE]
GEORGES MEAUZE *In* AGARD Transonic and Supersonic Phenomena in Turbomachines 12 p Mar. 1987 In FRENCH; ENGLISH summary
Avail: NTIS HC A16/MF A01

Incidence phenomenon, well known for supersonic straight cascades, is analyzed and extended in the general case of a cascade of a stream-surface with variable radius and thickness. The special configuration of a radial cascade is studied in detail. From this analysis, it is possible to point out some rules for the optimization of the entrance part of supersonic cascades. Author

N87-22097*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
FULL-SCALE ENGINE DEMONSTRATION OF AN ADVANCED SENSOR FAILURE DETECTION, ISOLATION AND ACCOMMODATION ALGORITHM: PRELIMINARY RESULTS
WALTER C. MERRILL, JOHN C. DELAAT, STEVEN M. KROSZKEWICZ, and MAHMOOD ABDELWAHAB 1987 14 p Proposed for presentation at the Guidance, Navigation and Control Conference, Monterey, Calif., 17-19 Aug. 1987; sponsored by AIAA
(NASA-TM-89880; E-3561; NAS 1.15:89880; AIAA-87-2259)
Avail: NTIS HC A02/MF A01 CSCL 09C

The objective of the advanced detection, isolation, and accommodation (ADIA) program is to improve the overall demonstrated reliability of digital electronic control systems for turbine engines. For this purpose, algorithms were developed which detect, isolate, and accommodate sensor failures using analytical redundancy. Preliminary results of a full scale engine demonstration of the ADIA algorithm are presented. Minimum detectable levels of sensor failures for an F100 turbofan engine control system are determined and compared to those obtained during a previous evaluation of this algorithm using a real-time hybrid computer simulation of the engine. Author

N87-22116*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NUMERICAL SIMULATION OF THE HYPERSONIC FLOW AROUND LIFTING VEHICLES
YEHIA RIZK (Sterling Federal Systems, Inc., Palo Alto, Calif.), DENNY CHAUSSEE, and JOSEPH STEGER Apr. 1987 28 p Presented at the Symposium on Aerodynamics of Hypersonic Lifting Vehicles, Bristol, England, 6-9 Apr. 1987; sponsored by AGARD
(NASA-TM-89444; A-87153; NAS 1.15:89444) Avail: NTIS HC A03/MF A01 CSCL 20D

A method for solving the viscous hypersonic flow field around realistic configurations is presented. The numerical procedure for generating the required finite difference grid and the two-factored implicit flow solver are described. Results are presented for the shuttle orbiter and a generic wing-body configuration at hypersonic Mach numbers. Author

N87-22136# Naval Postgraduate School, Monterey, Calif.
THE EFFECTS OF AN EMBEDDED VORTEX ON A FILM COOLED TURBULENT BOUNDARY LAYER M.S. Thesis
STEPHEN L. JOSEPH Dec. 1986 222 p
(Contract MIPR-FY1455-86-N0616)
(AD-A177785) Avail: NTIS HC A10/MF A01 CSCL 20D

Secondary flow effects on endwalls, blades, and combustion chambers of gas turbine engines are modelled. Measurements were made in a turbulent boundary layer developing over a flat plate, using a single row of injection holes spaced three diameters apart inclined at 30 degrees with respect to horizontal. The injection system was designed to provide uniform injection temperatures for various blowing rates with discharge coefficients ranging from 0.58 to 0.73. The heat transfer surface was designed to provide content heat flux with adjustable temperature range. Experimental heat transfer results were obtained with a turbulent boundary layer only, with boundary layer and injection of film cooling, with boundary layer and embedded vortex, and finally with boundary layer, film cooling, and embedded vortex. The effects of the vortex on heat transfer in the film cooled boundary layer are significant and important: (1) On the downwash side of the vortex, heat transfer is augmented, effects of the film cooling are negated and local hot spots will exist in engines. (2) Near the upwash side of the vortex coolant is pushed to the side of the vortex, appearing to augment the protection provided by film cooling. Author

N87-22138# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
COMPUTATION OF UNSTEADY FLOWS USING THE POINT VORTEX METHOD [CALCUL D'ECOULEMENTS INSTATIONNAIRES PAR LA METHODE DES TOURBILLONS PONCTUELS]
Y. MORCHOISNE *In* AGARD Round Table Discussion on Modelling of Time-Variant Flows Using Vortex Dynamics 15 p Feb. 1987 In FRENCH
Avail: NTIS HC A06/MF A01

The computation of unsteady flow of an inviscid, incompressible fluid around wing, rotor, or fuselage configurations may be carried out with the various singularity methods. The object of this report is to briefly describe the doublet-point vortex methods and discuss some applications which have been recently investigated including a double delta wing, a rotor in forward flight, a helicopter fuselage, and a helicopter in forward flight. M.G.

N87-22139# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. for Theoretical Fluid Mechanics.
VORTEX DYNAMICS: A REPORT ON WORK IN GERMANY
H. OERTEL *In* AGARD Round Table Discussion on Modelling of Time-Variant Flows Using Vortex Dynamics 10 p Feb. 1987
Avail: NTIS HC A06/MF A01

This article reviews the numerical work relevant to the vortex dynamics method carried out in Germany supplemented by results from the Franco-German Research Institute Saint Louis, ISL. The introduction includes the development of two- and three-dimensional simulation methods and is followed by a discussion of the results in shear layers, trailing far wakes, aerodynamical profile flow simulation with spoiler and the simulation of three-dimensional structures in wakes. Author

N87-22140# Defense Industries Directorate, Athens (Greece).
SIMULATION OF IMPINGING SHEAR LAYERS USING VORTEX DYNAMICS
ARGYRIS G. PANARAS *In* AGARD Round Table Discussion on Modelling of Time-Variant Flows Using Vortex Dynamics 26 p Feb. 1987
Avail: NTIS HC A06/MF A01

Organized vortices have been observed within the oscillating shear layers that impinge on a surface. It is believed that the feedback force necessary for the generation of these vortices is produced by their interaction with the reattachment surface. In the present work, models for studying the interaction of lines or of finite-area vortices with edges that simulate cavity-type of flows or edge-tones are examined. According to the analysis, the interaction of vortices with an edge induces periodic pressure fluctuations similar to those measured in oscillating flows. Also, when the geometry of an edge is such that no oscillation has been observed, the amplitude of the induced pressure pulses is insignificant. Thus, the hypothesis about the role of the vortex/edge interaction is supported. Author

N87-22149# Office National d'Etudes et de Recherches Aerospatiales, Toulouse (France).
THREE-DIMENSIONAL LAYERS: LAMINAR-TURBULENT TRANSITION
DANIEL ARNAL *In* AGARD Computation of Three-Dimensional Boundary Layers Including Separation 34 p Feb. 1987
Avail: NTIS HC A10/MF A01

The first part of this paper is devoted to a brief survey of transition problems in two-dimensional flows. The main elements of laminar instability theory are presented and used for elaborating some practical transition criteria. In three-dimensional situations, the problem is much more complex, because transition may occur through streamwise instability, cross-flow instability or leading edge contamination. It is assumed that the streamwise instability can be studied by using two-dimensional results. On the contrary, the cross-flow instability and the leading edge contamination constitute typical features of three-dimensional flows, as it is illustrated by experimental results. The extension of linear stability theory to these last problems is discussed, and transition criteria are developed. Moreover an intermittency method allows the transition region to be calculated. These techniques are applied to swept wings and bodies at incidence. Author

N87-22151# Douglas Aircraft Co., Inc., Long Beach, Calif.
AN APPROACH TO PRACTICAL AERODYNAMIC CALCULATIONS
TUNCER CEBECI *In* AGARD Computation of Three-Dimensional Boundary Layers Including Separation 40 p Feb. 1987
Avail: NTIS HC A10/MF A01

The emphasis of these lectures is on the numerical solution of three-dimensional boundary-layer equations using forms of Keller's Box scheme and interaction with solutions of inviscid-flow equations. Calculations are described for the flow over a circular cylinder started impulsively from rest and a prolate spheroid at angle of attack, and were obtained with prescribed free-stream velocity distribution; the results emphasize the need for the Characteristic Box finite-difference scheme, which automatically satisfies the numerical stability criterion, in regions of flow where the w-velocity component is negative. Corresponding calculations, this time with a novel interactive method, are reported for the flow over the leading edge of a thin ellipse, over an oscillating airfoil and around wings; the results confirm that the interactive procedure provides accurate solutions, without numerical problems, in regions of flow separation. Author

N87-22152# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
PROGRESS IN VISCOUS-INVISCID SOLVERS (VIS)
J. C. LEBALLEUR *In* AGARD Computation of Three-Dimensional Boundary Layers Including Separation 3 p Feb. 1987
Avail: NTIS HC A10/MF A01

The aim of these lectures was an introduction to the further extensions of boundary layer theory, which rely on the development of full viscous-inviscid interaction solvers, in three-dimensional flows. At the present time, however, the state of the art still does not accommodate the full 3D-problem. It is more or less restricted, on one hand, to advances in uncoupled 3D-boundary layer problems, direct or inverse, and, on the other hand, to developments in full viscous-inviscid solvers for the 2D or quasi-3D infinite swept wing flows, the latter developments involving the coupling and the calculation of quasi-3D closed separations. The present lectures were mainly devoted to the developments obtained by the author and his colleagues in these two areas. These developments were outlined after describing shortly the different strategies which can be used to split the Navier-Stokes problem into a viscous-inviscid interaction problem, in two or three dimensions. Author

N87-22153# Scientific Research Associates, Inc., Glastonbury, Conn.
COMPUTATION OF TIP AND CORNER REGION FLOWS
T. R. GOVINDAM and H. MCDONALD *In* AGARD Computation of Three-Dimensional Boundary Layers Including Separation 20 p Feb. 1987
Avail: NTIS HC A10/MF A01

The flow field in corner and tip regions of wings and propellers is complex, three-dimensional, and viscous with large secondary/transverse velocities. The large secondary velocities, usually associated with streamwise vorticity development in the flow, preclude the use of conventional boundary-layer solution techniques to compute such flow fields. On the other hand, solution techniques for the full Navier-Stokes equations that adequately resolve the length scales of tip and corner region flow fields would require formidable computer resources for use routinely. Sets of approximate three-dimensional viscous flow equations which are applicable to tip and corner region flow fields and which can be solved economically are sought. Clearly, economy of solution must result from approximations to the governing equations for such procedures to be attractive. A spatial marching computation procedure that solves approximate three-dimensional viscous flow equations economically is presented here and application of the procedure to compute tip and corner region flow fields discussed. Author

N87-22167# National Aeronautical Lab., Bangalore (India). Propulsion Div.
THROUGH FLOW ANALYSIS WITHIN AXIAL FLOW TURBOMACHINERY BLADE ROWS
H. GIRIGOSWAMI Sep. 1986 16 p
(NAL-PD-PR-8609) Avail: NTIS HC A02/MF A01

Using Katsanis' Through Flow Code, inviscid flow through an axial flow compressor rotor blade as well as flow through inlet guide vanes are analyzed and the computed parameters such as meridional velocity distribution, axial velocity distribution along radial lines, and velocity distribution over blade surfaces are presented. Author

N87-22169# National Aerospace Lab., Tokyo (Japan).
ESTIMATION OF DIVERGENCE AND FLUTTER BOUNDARIES FROM LOCALLY STATIONARY RANDOM RESPONSES
YASUKATSU ANDO and YUJI MATSUZAKI 1986 16 p In JAPANESE; ENGLISH summary
(NAL-TR-898; ISSN-0389-4010) Avail: NTIS HC A02/MF A01

A local, stationary process method for predicting flutter and divergence boundaries is presented. The method was applied to response signals of wing models due to flow turbulence measured in subcritical flutter and divergence tests in which the dynamic pressure was increased at a constant speed with the Mach number being fixed. A long nonstationary response record was divided into many contiguous equally short intervals in which the response was assumed to be locally stationary. The random response was assumed to be represented by the autoregressive process. The parameters of the process were evaluated by Akaike's automatic estimation procedure. The estimated values of Jury's stability parameters in each interval are quite scattered. It is shown, however, that the stability boundaries can be predicted by drawing a straight line as the upper side of an envelope for the scattering estimated values of the stability parameters. Author

N87-22181*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
USE OF A LIQUID-CRYSTAL, HEATER-ELEMENT COMPOSITE FOR QUANTITATIVE, HIGH-RESOLUTION HEAT TRANSFER COEFFICIENTS ON A TURBINE AIRFOIL, INCLUDING TURBULENCE AND SURFACE ROUGHNESS EFFECTS
STEVEN A. HIPPENSTEELE, LOUIS M. RUSSELL, and FELIX J. TORRES May 1987 16 p Presented at the Winter Annual Meeting of the American Society of Mechanical Engineers, Anaheim, Calif., 7-12 Dec. 1986
(NASA-TM-87355; E-3021; NAS 1.15:87355) Avail: NTIS HC A02/MF A01 CSCL 14B

Local heat transfer coefficients were measured along the midchord of a three-times-size turbine vane airfoil in a static cascade operated at roon temperature over a range of Reynolds numbers. The test surface consisted of a composite of commercially available materials: a Mylar sheet with a layer of cholestric liquid crystals, which change color with temperature, and a heater made of a polyester sheet coated with vapor-deposited gold, which produces uniform heat flux. After the initial selection and calibration of the composite sheet, accurate, quantitative, and continuous heat transfer coefficients were mapped over the airfoil surface. Tests were conducted at two free-stream turbulence intensities: 0.6 percent, which is typical of wind tunnels; and 10 percent, which is typical of real engine conditions. In addition to a smooth airfoil, the effects of local leading-edge sand roughness were also examined for a value greater than the critical roughness. The local heat transfer coefficients are presented for both free-stream turbulence intensities for inlet Reynolds numbers from 1.20 to 5.55 x 10 to the 5th power. Comparisons are also made with analytical values of heat transfer coefficients obtained from the STAN5 boundary layer code. Author

N87-22199*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
ROTORDYNAMIC INSTABILITY PROBLEMS IN HIGH-PERFORMANCE TURBOMACHINERY, 1986
Jan. 1987 548 p Workshop held in College Station, Tex., 2-4 Jun. 1986; sponsored in cooperation with Texas A&M Univ., Army Research Office, and Air Force Aeropropulsion Lab.
(NASA-CP-2443; E-3136; NAS 1.55:2443) Avail: NTIS HC A23/MF A01 CSCL 13I

The first rotordynamics workshop proceedings (NASA CP-2133, 1980) emphasized a feeling of uncertainty in predicting the stability of characteristics of high-performance turbomachinery. In the second workshop proceedings (NASA CP-2250, 1982) these uncertainities were reduced through programs established to systematically resolve problems, with emphasis on experimental validiation of the forces that influence rotordynamics. In third proceedings (NASA CP-2338, 1984) many programs for predicting or measuring forces and force coefficients in high-performance turbomachinery produced results. Data became available for designing new machines with enhanced stability characteristics or for upgrading existing machines. The present workshop proceedings illustrates a continued trend toward a more unified view of rotordynamic instability problems and several encouraging new analytical developments.

N87-22200*# Dresser Industries, Inc., Olean, N.Y.
A HISTORY OF DEVELOPMENT IN ROTORDYNAMICS: A MANUFACTURER'S PERSPECTIVE
DAVID E. SHEMELD *In* NASA. Lewis Research Center Rotordynamic Instability Problems in High-Performance Turbomachinery, 1986 p 1-18 Jan. 1987
Avail: NTIS HC A23/MF A01 CSCL 13I

The subject of rotordynamics and instability problems in high performance turbomachinery has been a topic of considerable industry discussion and debate over the last 15 or so years. This paper reviews an original equipment manufacturer's history of development of concepts and equipment as applicable to multistage centrifugal compressors. The variety of industry user compression requirements and resultant problematical situations tends to confound many of the theories and analytical techniques set forth. The experiences and examples described herein support the conclusion that the successful addressing of potential rotordynamics problems is best served by a fundamental knowledge of the specific equipment. This in addition to having the appropriate analytical tools. Also, that the final proof is in the doing. Author

N87-22210*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
INFLUENCE OF DISK LEAKAGE PATH ON LABYRINTH SEAL INLET SWIRL RATIO
R. GORDON KIRK *In* NASA. Lewis Research Center Rotordynamic Instability Problems in High-Performance Turbomachinery, 1986 p 225-236 Jan. 1987
Avail: NTIS HC A23/MF A01 CSCL 13I

The results of numerous investigators have shown the importance of labyrinth seal inlet swirl on the calculated dynamic stiffness of labyrinth seals. These results have not included any calculation of inlet leakage swirl as a function of geometry and sealing conditions of the given seal. This paper outlines a method of calculating the inlet swirl at a given seal by introducing a radial chamber to predict the gas swirl as it goes from the stage tip down to the seal location. For a centrifugal compressor, this amounts to including the flow path from the impeller discharge, down the back of the disk or front of the cover, then into the shaft seal or eye packing, respectively. The solution includes the friction factors of both the disk and stationary wall with account for mass flow rate and calculation of radial pressure gradients by a free vortex solution. The results of various configurations are discussed and comparisons made to other published results of disk swirl. Author

N87-22212*# Texas A&M Univ., College Station.
EXPERIMENTAL ROTORDYNAMIC COEFFICIENT RESULTS FOR TEETH-ON-ROTOR AND TEETH-ON-STATOR LABYRINTH GAS SEALS
DARA W. CHILDS and JOSEPH K. SCHARRER *In* NASA. Lewis Research Center Rotordynamic Instability Problems in High-Performance Turbomachinery, 1986 p 259-275 Jan. 1987
(Contract NAS3-181; F49620-82-K-0033)
Avail: NTIS HC A23/MF A01 CSCL 13I

An experimental test facility is used to measure the rotordynamic coefficients of teeth-on-rotor and teeth-on-stator labyrinth gas seals. Direct damping coefficients are presented for these seals for the first time. The results are presented for the two seal configurations at identical operating conditions, and show that, in a rotordynamic sense, the teeth-on-stator seal is more stable than the teeth-on-rotor seal, for inlet tangential velocity in the direction of rotation. Author

N87-22213*# Liverpool Univ. (England).
NON-LINEAR IDENTIFICATION OF A SQUEEZE-FILM DAMPER
ROGER STANWAY, JOHN MOTTERSHEAD, and RIAZ FIROOZIAN *In* NASA. Lewis Research Center Rotordynamic Instability Problems in High-Performance Turbomachinery, 1986 p 277-291 Jan. 1987
Avail: NTIS HC A23/MF A01 CSCL 13I

Described is an experimental study to identify the damping laws associated with a squeeze-film vibration damper. This is achieved by using a non-linear filtering algorithm to process displacement responses of the damper ring to synchronous excitation and thus to estimate the parameters in an nth-power velocity model. The experimental facility is described in detail and a representative selection of results is included. The identified models are validated through the prediction of damper-ring orbits and comparison with observed responses. Author

N87-22215*# Garrett Corp., Phoenix, Ariz.
INSTABILITY OF AN INTERSHAFT SQUEEZE FILM DAMPER IN A TWO-SPOOL ROTOR DYNAMICS SIMULATOR
R. G. ALDERSON *In* NASA. Lewis Research Center Rotordynamic Instability Problems in High-Performance Turbomachinery, 1986 p. 315-323 Jan. 1987
Avail: NTIS HC A23/MF A01 CSCL 13I

An instability associated with an intershaft squeeze film damper is described. The squeeze film is located between the intershaft bearing outer race and the low-speed shaft of a five-bearing, two-spool test rig. The instability is dominated by response of the third system mode to destabilizing excitation of the type described by Hibner, et al. Installing a spring cage in place of the intershaft damper removes the instability and produces satisfactory performance throughout the operating range. Author

N87-22216*# Heriot-Watt Univ., Edinburgh (Scotland).
A NOVEL FORM OF DAMPER FOR TURBO-MACHINERY
R. D. BROWN and J. A. HART *In* NASA. Lewis Research Center Rotordynamic Instability Problems in High-Performance Turbomachinery, 1986 p 325-347 Jan. 1987
Avail: NTIS HC A23/MF A01 CSCL 13I

Anti-swirl vanes are used by some manufacturers to delay the full development of half speed circulation in annular clearance spaces. The objective is to reduce the aerodynamic cross-coupling in the forward direction. The novel feature of a jet damper is a number of tangential nozzles discharging against the rotor surface speed. Some preliminary results on a 33.9 Kg rotor demonstrate that significant reductions in amplitude are obtained at the synchronous critical speeds. Author

N87-22217*# Southampton Univ. (England).
NON-LINEAR PERFORMANCE OF A THREE-BEARING ROTOR INCORPORATING A SQUEEZE-FILM DAMPER
R. HOLMES and M. DEDE *In* NASA. Lewis Research Center Rotordynamic Instability Problems in High-Performance Turbomachinery, 1986 p 349-364 Jan. 1987
Avail: NTIS HC A23/MF A01 CSCL 13I

This paper is concerned with the non-linear vibration performance of a rigid rotor supported on three bearings, one being surrounded by a squeeze-film damper. This damper relies on the pressure built up in the squeeze film to help counter-act external forces arising from unbalance and other effects. As a result a vibration orbit of a certain magnetude results. Such vibration orbits illustrate features found in other non-linear systems, in particular sub-harmonic resonances and jump phenomena. Comparisons between theoretical prediction and experimental observations of these phenomena are made. Author

N87-22219*# Texas A&M Univ., College Station.
EXPERIMENTAL MEASUREMENT OF THE DYNAMIC PRESSURE DISTRIBUTION IN A SQUEEZE FILM BEARING DAMPER EXECUTING CIRCULAR CENTERED ORBITS
L. A. SANANDRES and J. M. VANCE *In* NASA. Lewis Research Center Rotordynamic Instability Problems in High-Performance Turbomachinery, 1986 p 373-396 Jan. 1987
Avail: NTIS HC A23/MF A01 CSCL 13I

A review of previous experimental measurements of squeeze film damper (SFD) forces is given. Measurements by the authors of SFD pressure fields and force coefficients, for circular centered orbits with epsilon = 0.5, are described and compared with computer predictions. For Reynolds numbers over the range 2-6, the effect of fluid inertia on the pressure fields and forces is found to be significant. Author

N87-22234# Flow Research, Inc., Kent, Wash. Automation Inspection and Controls Div.
OPTICAL INTERFEROMETRY DIMENSIONAL GAUGE FOR DIMENSIONAL GAUGING OF PRECISION HIGH SPEED AIRCRAFT BEARING COMPONENTS Final Report, Apr. - Nov. 1986
ROGER F. JOHNSON Nov. 1986 24 p
(Contract F33657-85-C-2280)
(AD-A177338; FLOW-TD-390; ASD-TR-87-5008) Avail: NTIS HC A02/MF A01 CSCL 13I

This report describes the design and test of an optical interferometric dimensional gauge used for precision bearing components. The system's requirements and goals are addressed for each of the gauge components - air bearings, magnetic levitation and translation, interferometers, gauge stations, electronics hardware. In addition, tests and evaluations are covered for gauging accuracy and repeatability and temperature effects. Results of gauging forty 11/16-inch balls and forty 3/4-inch balls are included to demonstrate the measuring capability. GRA

N87-22245*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.
DEVELOPMENT OF GAS-TO-GAS LIFT PAD DYNAMIC SEALS, VOLUMES 1 AND 2 Final Report
A. N. POPE and D. W. PUGH May 1987 189 p
(Contract NAS3-20043)
(NASA-CR-179486; NAS 1.26:179486; R87-AEB432) Avail: NTIS HC A09/MF A01 CSCL 11A

Dynamic tests were performed on self acting (hydrodynamic) carbon face rotary shaft seals to assess their potential, relative to presently used labyrinth seals, for improving performance of aircraft gas turbine engines by reducing air leakage flow rate at compressor end seal locations. Three self acting bearing configurations, designed to supply load support at the interface of the stationary carbon seal and rotating seal race, were tested. Two configurations, the shrouded taper and shrouded flat step, were incorporated on the face of the stationary carbon seal element. The third configuration, inward pumping spiral grooves, was incorporated on the hard faced surface of the rotating seal race. Test results demonstrated seal leakage air flow rates from 75 to 95% lower that can be achieved with best state-of-the-art labyrinth designs and led to identification of the need for a more geometrically stable seal design configuration which is presently being manufactured for subsequent test evaluation. Author

N87-22251# Construcciones Aeronauticas S.A., Madrid (Spain). Dept. of System Engineering.
ROBOTS APPLIED TO NONDESTRUCTIVE INSPECTION (PROJECT SIRO)
J. I. MOLINA 1984 4 p
(ETN-87-99845) Avail: NTIS HC A02/MF A01

The SIRO, robotized nondestructive inspection system for aircraft manufacturing is described. Operational performance and flexibility, integration within a CAD/CAM environment, and ultrasonic options are discussed. ESA

N87-22267*# General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.
ELEVATED TEMPERATURE CRACK GROWTH Annual Report
S. N. MALIK, R. H. VANSTONE, K. S. KIM, and J. H. LAFLEN Jan. 1987 43 p
(Contract NAS3-23940)
(NASA-CR-179601; NAS 1.26:179601) Avail: NTIS HC A03/MF A01 CSCL 20K

The objective of the Elevated Temperature Crack Growth Program is to evaluate proposed nonlinear fracture mechanics methods for application to hot section components of aircraft gas turbine engines. Progress during the past year included linear-elastic fracture mechanics data reduction on nonlinear crack growth rate data on Alloy 718. The bulk of the analytical work centered on thermal gradient problems and proposed fracture mechanics parameters. Good correlation of thermal gradient

experimental displacement data and finite element prediction was obtained. Author

N87-22270*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STATIC AEROELASTIC EFFECTS ON THE FLUTTER OF A SUPERCRITICAL WING
E. CARSON YATES, JR. and LI-CHUAN CHU (PRC Kentron, Inc., Hampton, Va.) Mar. 1987 16 p Presented at the Specialists Meeting on Static Aeroelastic Effects on High Performance Aircraft at the 63rd Meeting of the AGARD Structures and Materials Panel, Athens, Greece, 28 Sep. - 3 Oct. 1986
(NASA-TM-89132; NAS 1.15:89132) Avail: NTIS HC A02/MF A01 CSCL 20K

It is well known that wings with supercritical airfoils generally have lower transonic flutter speeds than similar wings with conventional airfoils and that small increases in angle of attack from zero and the accompanying static aeroelastic deformations have further detrimental effects on transonic flutter. The results of an effort to calculate the effects of angle of attack and the associated aeroelastic deformation on the flutter of a highly swept supercritical wing (TF 8A) by use of the modified strip analysis employed in previous studies of this wing are presented. The spanwise distributions of steady-state section lift-curve slope and aerodynamic center required as input for these calculations were obtained from static aeroelastic calculations for the wing by use of the FL022 transonic code and an assumed dynamic pressure as that used to calculate the statically deformed shape and loading about which the flutter oscillation occurs. The results show that the unconventional backward turn of the transonic dip in the experimental flutter boundary for angles of attack greater than zero is caused by variations in mass ratio and not by static aeroelastic deformation, although inclusion of the latter appears to be required for quantitative accuracy in the calculations. Author

N87-22273*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
STRUCTURAL AND AEROELASTIC ANALYSIS OF THE SR-7L PROPFAN
MURRAY HIRSCHBEIN, ROBERT KIELB, ROBERT AIELLO, MARSHA NALL, and CHARLES LAWRENCE Mar. 1985 31 p
(NASA-TM-86877; E-2338; NAS 1.15:86877) Avail: NTIS HC A03/MF A01 CSCL 20K

A structural and aeroelastic analysis of a large scale advanced turboprop rotor blade is presented. This 8-blade rotor is designed to operate at Mach 0.8 at an altitude of 35,000 ft. The blades are highly swept and twisted and of spar/shell construction. Due to the complexity of the blade geometry and its high performance, it is subjected to much higher loads and tends to be much less stable than conventional blades. Four specific analyses were conducted: (1) steady deflection; (2) natural frequencies and mode shapes; (3) steady stresses; and (4) aeroelastic stability. State-of-the-art methods were used to analyze the blades including a large deflection, finite element structural analysis, and an aeroelastic analysis including interblade aerodynamic coupling (cascade effects). The study found the blade to be structurally sound and aeroelastically stable. However, it clearly indicated that advanced turboprop blades are much less robust than conventional blades and must be analyzed and fabricated much more carefully in order to assure that they are structurally sound and aeroelastically stable. Author

N87-22276*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
AN EXPERIMENTAL INVESTIGATION OF THE AEROMECHANICAL STABILITY OF A HINGELESS ROTOR IN HOVER AND FORWARD FLIGHT
WILLIAM T. YEAGER, JR., M-NABIL H. HAMOUDA (PRC Kentron, Inc., Hampton, Va.), and WAYNE R. MANTAY Jun. 1987 20 p
(Contract DA PROJ. 1L1-62209-AH-76B)
(NASA-TM-89107; L-16280; NAS 1.15:89107; AVSCOM-TM-87-B-5) Avail: NTIS HC A02/MF A01 CSCL 20K

Analysis and testing were conducted in the Langley Transonic Dynamics Tunnel to investigate the aeromechanical stability of a soft inplane hingeless rotor model. Rotor stability data were obtained in hover and in forward flight up to an advance ratio of 0.35. Model rotor parameters evaluated were blade sweep and droop, pre-cone of the blade feathering axis, and blade pitch-flap coupling. Data obtained during these tests are presented without analysis. Author

N87-22610*# Ohio Univ., Athens.
DIGITAL AUTONOMOUS TERMINAL ACCESS COMMUNICATION (DATAC) SYSTEM
STANLEY M. NOVACKI, III *In* NASA. Langley Research Center Joint University Program for Air Transportation Research, 1984 p 49-56 May 1987
Avail: NTIS HC A08/MF A01 CSCL 17B

In order to accommodate the increasing number of computerized subsystems aboard today's more fuel efficient aircraft, the Boeing Co. has developed the DATAC (Digital Autonomous Terminal Access Control) bus to minimize the need for point-to-point wiring to interconnect these various systems, thereby reducing total aircraft weight and maintaining an economical flight configuration. The DATAC bus is essentially a local area network providing interconnections for any of the flight management and control systems aboard the aircraft. The task of developing a Bus Monitor Unit was broken down into four subtasks: (1) providing a hardware interface between the DATAC bus and the Z8000-based microcomputer system to be used as the bus monitor; (2) establishing a communication link between the Z8000 system and a CP/M-based computer system; (3) generation of data reduction and display software to output data to the console device; and (4) development of a DATAC Terminal Simulator to facilitate testing of the hardware and software which transfer data between the DATAC's bus and the operator's console in a near real time environment. These tasks are briefly discussed. E.R.

N87-22611*# Ohio Univ., Athens.
FIBER OPTIC DATA TRANSMISSION
STEVEN T. SHREVE *In* NASA. Langley Research Center Joint University Program for Air Transportation Research, 1984 p 57-59 May 1987
Avail: NTIS HC A08/MF A01 CSCL 17B

The Ohio University Avionics Engineering Center is currently developing a fiber optic data bus transmission and reception system that could eventually replace copper cable connections in airplanes. The original form of the system will transmit information from an encoder to a transponder via a fiber optic cable. An altimeter and an altitude display are connected to a fiber optic transmitter by copper cable. The transmitter converts the altimetry data from nine bit parallel to serial form and send these data through a fiber optic cable to a receiver. The receiver converts the data using a cable similar to that used between the altimeter and display. The transmitting and receiving ends also include a display readout. After completion and ground testing of the data bus, the system will be tested in an airborne environment. Author

N87-22767*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
UNSTEADY STATOR/ROTOR INTERACTION
PHILIP C. E. JORGENSON and RODRICK V. CHIMA *In its* Structural Integrity and Durability of Reusable Space Propulsion Systems p 5-11 1987
Avail: NTIS HC A10/MF A01 CSCL 20D

The major thrust of the computational analysis of turbomachinery to date has been the steady-state solution of isolated blades using mass-averaged inlet and exit conditions. Unsteady flows differ from the steady solution due to interaction of pressure waves and wakes between blade rows. To predict the actual complex flow conditions one must look at the time accurate solution of the entire turbomachine. Three quasi-three-dimensional Euler and thin layer Navier-Stokes equations are solved for unsteady turbomachinery flows. Author

N87-22796*# Georgia Inst. of Tech., Atlanta.
NONISOTHERMAL ELASTO-VISCO-PLASTIC RESPONSE OF SHELL-TYPE STRUCTURES
G. J. SIMITSES, R. L. CARLSON, and R. RIFF *In* NASA. Lewis Research Center Structural Integrity and Durability of Reusable Space Propulsion Systems p 207-214 1987
(Contract NAG3-534)
Avail: NTIS HC A10/MF A01 CSCL 20K

A mathematical model and solution methodologies for analyzing structural response of thin, metallic shell-type structures under large transient, cyclic or static thermomechanical loads is disussed. Among the system responses, which are associated with these load conditions, are thermal buckling and creep buckling. Thus, geometric as well as material-type nonlinearities (of high order) can be anticipated and have been considered in the development of the mathematical model. Furthermore, this was accommodated in the solution procedures. A complete true ab-inito rate theory of kinematics and kinetics for continuum and curved thin structures, without any restriction on the magnitude of the strains or the deformation, was formulated. The time dependence and large strain behavior are incorporated through the introduction of the time rates of the metric and curvature in two coordinate systems, a fixed (spatial) one and a convected (material) coordinate system. The relations between the time derivative and the covariant derivatives (gradients) have been developed for curved space and motion, so that the velocity components supply the connection between the equations of motion and the time rate of change of the metric and curvature tensors. Author

N87-22928# Pennsylvania State Univ., University Park. Dept. of Mechanical Engineering.
EXPERIMENTAL RESEARCH ON COMPRESSIBLE TURBULENT SHEAR LAYERS, VISCOUS-INVISCID INTERACTIONS, AND FLOW SEPARATION Final Report
GARY S. SETTLES 9 Apr. 1986 14 p
(Contract AF-AFOSR-0184-84)
(AD-A179579; PSU-ME-86-R-0113; AFOSR-87-0452TR) Avail: NTIS HC A02/MF A01 CSCL 20D

This report describes the DoD-University Research Instrumentation Program Equipment Acquisition for Pennsylvania Univ. The thrust of this effort has been to outfit and upgrade Penn State's Supersonic Wind Tunnel Laboratory with modern instrumentation so that research in support of national defense can be conducted. The subject area of this research is viscous-inviscid interactions in supersonic flight. GRA

N87-22929# Cincinnati Univ., Ohio. Coll. of Engineering.
COMPOSITE VELOCITY PROCEDURES FOR FLOWS WITH PRESSURE INTERACTION Annual Technical Report, 1 Feb. 1985 - 1 Feb. 1986
STANLEY G. RUBIN and PREM K. KHOSLA 17 Mar. 1986 44 p
(Contract F49620-85-C-0027)
(AD-A179602; AFOSR-87-0357TR) Avail: NTIS HC A03/MF A01 CSCL 20D

The composite velocity formulation for the Euler and Reduced Navier-Stokes system of equations has been investigated. For transonic steady flow over airfoils a combination of conservative and nonconservative flux directional systems of difference equations have been developed and applied to obtain full potential, Euler and Reduced Navier Stokes solutions. The Enquist Osher procedure for shock capturing has been adapted for these applications to obtain sharp shock waves for both potential and Euler equations. For two dimensional transient flows and for three dimensional global relaxation computations, the coupled strongly implicit matrix inversion algorithm has been reformulated in order to allow for time consistency and space marching efficieny, respectively. GRA

N87-22930# Mississippi State Univ., Mississippi State. Dept. of Mechanical and Nuclear Engineering.
EQUIPMENT FOR TURBULENT HEAT TRANSFER TEST APPARATUS Final Report
HUGH W. COLEMAN Aug. 1986 9 p
(Contract AF-AFOSR-0075-85)
(AD-A179612; AFOSR-87-0555TR) Avail: NTIS HC A02/MF A01 CSCL 14B

This grant was made for the purpose of acquiring the equipment and constructing a wind tunnel facility called the Turbulent Heat Transfer Test Apparatus (THTTA). The THTTA was designed specifically to provide quality heat transfer and fluid dynamics data for turbulent flow over rough surfaces. GRA

N87-22932*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
CONSERVATIVE ZONAL SCHEMES FOR PATCHED GRIDS IN 2 AND 3 DIMENSIONS
KRISTIN A. HESSENIUS Apr. 1987 97 p
(NASA-TM-88326; A-86317; NAS 1.15:88326) Avail: NTIS HC A05/MF A01 CSCL 20D

The computation of flow over complex geometries, such as realistic aircraft configurations, poses difficult grid generation problems for computational aerodynamicists. The creation of a traditional, single-module grid of acceptable quality about an entire configuration may be impossible even with the most sophisticated of grid generation techniques. A zonal approach, wherein the flow field is partitioned into several regions within which grids are independently generated, is a practical alternative for treating complicated geometries. This technique not only alleviates the problems of discretizing a complex region, but also facilitates a block processing approach to computation thereby circumventing computer memory limitations. The use of such a zonal scheme, however, requires the development of an interfacing procedure that ensures a stable, accurate, and conservative calculation for the transfer of information across the zonal borders. Author

N87-22938# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
A STUDY OF FLUID-DYNAMIC PRESSURE FIELDS ON COMPRESSOR REED VALVES M.S. Thesis
CLARENCE J. COLEMAN, JR. Dec. 1986 112 p
(AD-A178584; AFIT/GAE/AA/86-02) Avail: NTIS HC A06/MF A01 CSCL 20D

Reed values are spring-metal plates which commonly serve as intake and exhaust valves in refrigeration Compressor units. This thesis reports on an analytic and experimental study of flow through reed-valve-like inlet geometries. In the latter, with reservoir pressures up to 2 1/4 times ambient, the flow passed through a hole in a base plate, stagnated, and turned 90 degrees by a disk

centered over the hole, and directed radially outward between the base plate and the disk. Cover-plate-like geometries up to 3 times the diameter of the hole in the base plate, as well as modified base-plate geometries, were investigated. The analytic model used one dimensional (radially symmetric) compressible flow relations to model the inlet geometries in an initial supersonic region which accounted for friction and possible separation. Shock matching techniques were then employed to locate a shock and predict the properties of the flow just behind the shock. Finally, subsonic, isentropic, compressible equations were used to model the flow from the shock to the exit. The analytic modelling was compared with the experimental results and found to satisfactorily explain the qualitative and even quantitative nature of the flows. The results of this study suggest that reed-valve inlet geometries should have relatively thin and high-lipped inlet configurations so as to minimize total pressure loss. Author (GRA)

N87-22940# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
NUMERICAL STUDY OF HIGH SPEED VISCOUS FLOWS M.S. Thesis
KEITH B. JOCHUM Dec. 1986 80 p
(AD-A178639; AFIT/GAE/AA/86D-4) Avail: NTIS HC A05/MF A01 CSCL 20D

Thermal deformations induced by aerodynamic heating on high speed vehicles are an important concern in design. Since aerodynamic heating may have a significant effect on the performance of the vehicle, effective techniques for predicting the heat transfer and flow properties are required. The accuracy of numerical solutions depends on the grid used. Usually accurate prediction requires clustering of grid points near the surface of the body. Using an explicit algorithm to solve such problems results in the stability requirement for very small time steps to satisfy the stability bounds. To remove the time step retriction, fully implicit methods were investigated. Results for high speed flow past a circular wedge using an implicit flux splitting scheme are shown. Viscous blunt body flows are also computed and qualitative comparisons with the existing experimental data are given. In an effort to decrease the computational costs associated with the implicit algorithms for the Navier-Stokes equations, a relaxation algorithm is developed for the Approximate Navier-Stokes equations. Results for Couette flow and supersonic flow over a flat plate are obtained using this relaxation algorithm and compared to analytical and other numerical solutions. GRA

N87-22948*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
A LINEARIZED EULER ANALYSIS OF UNSTEADY FLOWS IN TURBOMACHINERY Final Report
KENNETH C. HALL and EDWARD F. CRAWLEY Jun. 1987 183 p
(Contract NSG-3079)
(NASA-CR-180987; NAS 1.26:180987) Avail: NTIS HC A09/MF A01 CSCL 20D

A method for calculating unsteady flows in cascades is presented. The model, which is based on the linearized unsteady Euler equations, accounts for blade loading shock motion, wake motion, and blade geometry. The mean flow through the cascade is determined by solving the full nonlinear Euler equations. Assuming the unsteadiness in the flow is small, then the Euler equations are linearized about the mean flow to obtain a set of linear variable coefficient equations which describe the small amplitude, harmonic motion of the flow. These equations are discretized on a computational grid via a finite volume operator and solved directly subject to an appropriate set of linearized boundary conditions. The steady flow, which is calculated prior to the unsteady flow, is found via a Newton iteration procedure. An important feature of the analysis is the use of shock fitting to model steady and unsteady shocks. Use of the Euler equations with the unsteady Rankine-Hugoniot shock jump conditions correctly models the generation of steady and unsteady entropy and vorticity at shocks. In particular, the low frequency shock displacement is correctly predicted. Results of this method are presented for a variety of test cases. Predicted unsteady transonic flows in channels are compared to full nonlinear Euler solutions obtained using time-accurate, time-marching methods. The agreement between the two methods is excellent for small to moderate levels of flow unsteadiness. The method is also used to predict unsteady flows in cascades due to blade motion (flutter problem) and incoming disturbances (gust response problem). M.G.

N87-22978*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
HELICOPTER TRANSMISSION TESTING AT NASA LEWIS RESEARCH CENTER
DAVID G. LEWICKI and JOHN J. COY Jun. 1987 18 p Presented at the Testing of Aerospace Transmissions Conference, Derby, England, 10 Jun. 1987; sponsored by the Institute of Mechanical Engineers
(NASA-TM-89912; E-3603; NAS 1.15:89912; AVSCOM-TR-87-C-10) Avail: NTIS HC A02/MF A01 CSCL 13I

The helicopter has evolved into a highly valuable air mobile vehicle for both military and civilian needs. The helicopter transmission requires advanced studies to develop a technology base for future rotorcraft advances. A joint helicopter transmission research program between the NASA Lewis Research Center and the U.S. Army Aviation Systems Command has existed since 1970. Program goals are to reduce weight and noise and to increase life and reliability. The current experimental activities at Lewis consist of full-scale helicopter transmission testing, a base effort in gearing technology, and a future effort in noise reduction technology. The experimental facilities at Lewis for helicopter transmission testing are described. A description of each of the rigs is presented along with some significant results and near-term plans. Author

N87-23004# Army Aviation Systems Command, St. Louis, Mo.
ANALYSIS OF STRUCTURES WITH ROTATING, FLEXIBLE SUBSTRUCTURES
A. S. HOPKINS and PETER LIKINS 1987 11 p
(AD-A178903) Avail: NTIS HC A02/MF A01 CSCL 20K

A new methodology has been developed for the dynamic analysis of flexible structures, parts of which may be experiencing discrete motion relative to other parts. It can represent the continuum deformations typically treated using finite element methods. In addition, it can also represent the discrete motion at joints traditionally available with multibody methods. After decomposing the structure into substructures and associating a frame of reference with each substructure, the equations of motion for each substructure can be written explicitly including contributions due to the frame of reference generalized coordinates. By expanding the set of constraints to include those that eliminate the redundancy introduced by the frame generalized coordinates, the equations of motion become amenable to solution. The first digital computer program using this methodology is the General Rotorcraft Aeromechanical Stability Program (GRASP). GRASP is limited to applications involving steady state rotation, but extension to arbitrary motions (including spin up) can be accomplished by the selective retention of nonlinear terms in this formulation. GRA

N87-23009*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PREDICTION OF SERVICE LIFE OF AIRCRAFT STRUCTURAL COMPONENTS USING THE HALF-CYCLE METHOD
WILLIAM L. KO May 1987 27 p
(NASA-TM-86812; H-1352; NAS 1.15:86812) Avail: NTIS HC A03/MF A01 CSCL 20K

The service life of aircraft structural components undergoing random stress cycling was analyzed by the application of fracture mechanics. The initial crack sizes at the critical stress points for the fatigue-crack growth analysis were established through proof load tests. The fatigue-crack growth rates for random stress cycles were calculated using the half-cycle method. A new equation was developed for calculating the number of remaining flights for the

structural components. The number of remaining flights predicted by the new equation is much lower than that predicted by the conventional equation. Author

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GEOSCIENCES

Includes geosciences (general); earth resources and remote sensing; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

N87-22314# Harris, Miller, Miller and Hanson, Inc., Lexington, Mass.
NOISEMAP 5.1 COMPUTER PROGRAM UPDATE. OPERATOR'S MANUAL, ADDENDUM 2 Final Report
RICHARD D. HORONJEFF Dec. 1986 30 p Previously announced as N79-29963
(Contract AF PROJ. 7231)
(AD-A177345; HMMH-260300-ADD-2; AAMRL-TR-78-109-ADD-2)
Avail: NTIS HC A03/MF A01 CSCL 09B

This report, an addendum to AMRL-TR-78-109, describes new capabilities for the NOISEMAP program that allows for the SAE AIR 1751 lateral attenuation algorithm to be substituted for the current NOISEMAP lateral attenuation algorithm for generating noise contours resulting from civil aircraft operations. When used in this mode for civil airport studies, the results normally agree within 0.5 dB with contours computed using the FAA Integrated Noise Model for the same civil aircraft operations. This version of NOISEMAP has been approved for Federal Aviation Regulation Part 150 studies when used with this option invoked. In addition, the NOISEMAP version number is now printed at the top of each output page. GRA

N87-22341*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
ATMOSPHERIC TURBULENCE RELATIVE TO AVIATION, MISSILE, AND SPACE PROGRAMS
DENNIS W. CAMP, ed. and WALTER FROST, ed. (FWG Associates, Inc., Tullahoma, Tenn.) Apr. 1987 257 p Workshop held in Hampton, Va., 2-4 Apr. 1986
(NASA-CP-2468; L-16296; NAS 1.55:2468) Avail: NTIS HC A12/MF A01 CSCL 04B

The purpose of the workshop was to bring together various disciplines of the aviation, missile, and space programs involved in predicting, measuring, modeling, and understanding the processes of atmospheric turbulence. Working committees re-examined the current state of knowledge, identified present and future needs, and documented and prioritized integrated and cooperative research programs.

N87-22346*# FWG Associates, Inc., Tullahoma, Tenn.
REMOTE VERSUS IN SITU TURBULENCE MEASUREMENTS
WALTER FROST *In* NASA. Langley Research Center Atmospheric Turbulence Relative to Aviation, Missile and Space Programs p 53-71 Apr. 1987
Avail: NTIS HC A12/MF A01 CSCL 04B

Comparisons of in situ wind and turbulence measurements made with the NASA B-57 instrumented aircraft and those remotely made with both radar and lidar systems are presented. Turbulence measurements with a lidar or radar system as compared with those from an aircraft are the principal themes. However, some discussion of mean wind speed and direction measurements is presented. First, the principle of measuring turbulence with Doppler lidar and radar is briefly and conceptually described. The comparisons with aircraft measurements are then discussed. Two studies in particular are addressed: one uses the JAWS Doppler radar data and the other uses data gathered both with the NASA Marshall Space Flight Center and the the NOAA Wave Propagation Lab. gound based lidars. Finally, some conclusions and recommendations are made. Author

N87-22347*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MEASUREMENTS OF ATMOSPHERIC TURBULENCE
HAROLD N. MURROW *In its* Atmospheric Turbulence Relative to Aviation, Missile and Space Programs p 73-92 Apr. 1987
Avail: NTIS HC A12/MF A01 CSCL 04B

Various types of atmospheric turbulence measurements are addressed for the purpose of stimulating discussion relative to available data. An outline of these various types of measurements are discussed. Some specific results of detailed characterization studies made at NASA Langley are emphasized. The most recent reports on statistics of turbulence encounters for various types of aircraft operations are summarized. Special severe encounter studies and reference to remote sensing are also included. Wind shear is considered to be a special topic and is not covered. Author

N87-22348*# National Severe Storms Lab., Norman, Okla.
TURBULENCE AS OBSERVED BY CONCURRENT MEASUREMENTS MADE AT NSSL USING WEATHER RADAR, DOPPLER RADAR, DOPPLER LIDAR AND AIRCRAFT
JEAN T. LEE *In* NASA. Langley Research Center Atmospheric Turbulence Relative to Aviation, Missile and Space Programs p 93-110 Apr. 1987
Avail: NTIS HC A12/MF A01 CSCL 04B

As air traffic increases and aircraft capability increases in range and operating altitude, the exposure to weather hazards increases. Turbulence and wind shears are two of the most important of these hazards that must be taken into account if safe flight operations are to be accomplished. Beginning in the early 1960's, Project Rough Rider began thunderstorm investigations. Past and present efforts at the National Severe Storm Laboratory (NSSL) to measure these flight safety hazards and to describe the use of Doppler radar to detect and qualify these hazards are summarized. In particular, the evolution of the Doppler-measured radial velocity spectrum width and its applicability to the problem of safe flight is presented. Author

N87-22351*# Delta Air Lines, Inc., Atlanta, Ga.
TURBULENCE FORECASTING
C. L. CHANDLER *In* NASA. Langley Research Center Atmospheric Turbulence Relative to Aviation, Missile and Space Programs p 137-154 Apr. 1987
Avail: NTIS HC A12/MF A01 CSCL 04B

In order to forecast turbulence, one needs to have an understanding of the cause of turbulence. Therefore, an attempt is made to show the atmospheric structure that often results when aircraft encounter moderate or greater turbulence. The analysis is based on thousands of hours of observations of flights over the past 39 years of aviation meteorology. Author

N87-22353*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EXAMPLE ON HOW TO MODEL AND SIMULATE TURBULENCE FOR FLIGHT SIMULATORS
JOHN C. HOUBOLT *In its* Atmospheric Turbulence Relative to Aviation, Missile and Space Programs p 159-178 Apr. 1987
Avail: NTIS HC A12/MF A01 CSCL 04B

Analytical developments relative to gust response are discussed. Turbulence length scale, spectral functions, zero crossing values, gust loads analysis, power spectral techniques for analyzing the response of aircraft in turbulence, the spectrum of the rolling moment coefficient, and the spectrum correction factor are among the issues considered. R.J.F.

N87-22355*# Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio.
THE STATUS OF MILITARY SPECIFICATIONS WITH REGARD TO ATMOSPHERIC TURBULENCE
DAVID J. MOORHOUSE and ROBERT K. HEFFLEY (Manudyne Systems, Inc., Los Altos, Calif.) *In* NASA. Langley Research Center Atmospheric Turbulence Relative to Aviation, Missile and Space Programs p 181-199 Apr. 1987
Avail: NTIS HC A12/MF A01 CSCL 04B

The features of atmospheric disturbances that are significant to aircraft flying qualities are discussed. Next follows a survey of proposed models. Lastly, there is a discussion of the content and application of the model contained in the current flying qualities specification and the forthcoming MIL-Standard. Author

N87-22375# National Weather Service, Garden City, N.Y.
WASHINGTON METROPOLITAN WIND STUDY, 1981-1986
C. BURKE and C. C. EWALD Feb. 1987 30 p
(PB87-151908; NOAA-TM-NWS-ER-71) Avail: NTIS HC A03/MF A01 CSCL 04B

The importance of wind direction and speed in the designation of the operational runway was the basis for this study. During the past five years from October 1, 1981, until October 7, 1986, almost 37,100 hourly wind observations from National (DCA), Dulles (IAD, Baltimore-Washington (BWI) and Andrews (ADW) airports were examined and 2013 observations or 5.4%, which met one of the 3 criteria listed below, were recorded. The study is divided into a separate section for each criterion. It is hoped that the results of the study represented by the numerous tables will improve the operational wind forecasts for these airports made by the Leesburg CWSU Meteorologists at the beginning of every shift. GRA

N87-22379# National Severe Storms Lab., Norman, Okla.
LOW ALTITUDE WIND SHEAR DETECTION WITH DOPPLER RADAR Final Report
MICHAEL D. EILTS Feb. 1987 40 p
(Contract DTFA01-80-Y-10524)
(DOT/FAA/PM-87/6) Avail: NTIS HC A03/MF A01

The feasibility of using the next generation weather radar (NEXRAD) system to detect low-altitude horizontal wind shear near airports is investigated. The surface-measured horizontal shear is compared with that observed aloft with Doppler radar to determine how the radar-estimated shear above the surface relates to the surface-measured shear. For five Oklahoma gust fronts, the Doppler radar estimate of shear averaged 1.6 times the shear measured at the surface. For none of 43 comparisons was the surface radial velocity difference across the gust front stronger than the radial velocity difference measured by the Doppler radar aloft. When the five gust fronts passed an instrumented tower a vertical profile through the lowest 440 m of the gust front could be determined. In all cases the peak wind shear was at a much higher altitude. Due to surface friction it is expected that wind speeds and shears in downbursts will also be stronger aloft than at the surface, however, further study is necessary. It is suggested that a combination of Doppler radar data and information gleaned from a Low-Level Wind Shear Alert System would allow more accurate wind shear estimates in the terminal area or airports than would be possible with either system by itself. Author

N87-23067# Federal Aviation Administration, Washington, D.C.
INTEGRATED FAA WIND SHEAR PROGRAM PLAN
Apr. 1987 95 p
(DOT/FAA/DL-87/1; DOT/FAA/VS-87/1; DOT/FAA/AT-87/1)
Avail: NTIS HC A05/MF A01

Wind shear can have serious and sometimes disastrous effects on the flight path of an aircraft, especially when encountered below 1,000 feet above the ground. In the last 10 years, wind shear was found to be a contributing factor in 14 major aircraft accidents, 4 of which resulted in a total of 401 casualties. Following these accidents, the National transportation Safety Board (NTSB) issued a number of recommendations urging the Federal Aviation Administration (FAA) to address the wind shear problem. Recommendations pertaining to wind shear were also issued by the National Research Council (NRC) in an in-depth study on wind shear published in 1983. The NTSB and NRC recommendations serve as a backdrop to the development of the Integrated FAA Wind Shear Program Plan. Program elements include education and training, ground sensors, airborne sensors and flight guidance systems, terminal information systems, and low-level meteorological hazard characterization. The plan emphasizes how each program element operationally relates to the others and incrementally adds to the overall National Airspace System safety.

N87-23100*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HIGH ALTITUDE TURBULENCE FOR SUPERSONIC CRUISE VEHICLES
L. J. EHERNBERGER May 1987 18 p Presented at the 33rd Annual Meeting of the American Astronautical Society, Boulder, Colo., 26-29 Oct. 1986
(NASA-TM-88285; H-1399; AAS-86-418; NAS 1.15:88285) Avail: NTIS HC A02/MF A01 CSCL 04B

The characterisitics of high altitude turbulence and its associated meteorological features are reviewed. Findings based on data from NASA flight research programs with prototype military aircraft, the XB-70 and YF-12A, are emphasized. An example of detailed numerical atmospheric simulations, which amy provide greatly increased understanding of these earlier turbulence observations, is presented. Comparisons between observation and numerical simulation should help to delineate the limitations of analysis techniques and improve our understanding of atmospheric processes in the stratosphere. Author

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A87-35714
A CONFIGURABLE PIXEL CACHE FOR FAST IMAGE GENERATION
ANDY GORIS, BOB FREDRICKSON, and HAROLD L. BAEVERSTAD, JR. (Hewlett-Packard Co., Fort Collins, CO) IEEE Computer Graphics and Applications (ISSN 0272-1716), vol. 7, March 1987, p. 24-32. refs

This article describes an approach to fast image generation that uses a high-speed serial scan converter, a somewhat slower frame buffer, and a pixel cache to match the bandwidth between the two. Cache hit rates are improved by configuring the cache to buffer either 4 x 4 or 16 x 1 tiles of frame buffer memory, depending on the type of operation being performed. For line drawing, the implementation described can process 300,000 30-pixel vectors per second. For shaded polygons, the system can fill 16,000 900-pixel polygons per second. In addition to buffering pixel intensity data, the pixel cache also buffers z (depth) values, improving the performance of the z-buffer hidden-surface algorithm. By utilizing z-value caching, the system can process 5800 900-pixel shaded polygons per second with hidden surfaces removed. Author

A87-35718* Arizona State Univ., Tempe.
A HYBRID NONLINEAR PROGRAMMING METHOD FOR DESIGN OPTIMIZATION
S. D. RAJAN (Arizona State University, Tempe) Journal of Structural Mechanics (ISSN 0360-1218), vol. 14, no. 4, 1986, p. 455-474. refs
(Contract NAG3-580)

Solutions to engineering design problems formulated as nonlinear programming (NLP) problems usually require the use of more than one optimization technique. Moreover, the interaction between the user (analysis/synthesis) program and the NLP system can lead to interface, scaling, or convergence problems. An NLP solution system is presented that seeks to solve these problems by providing a programming system to ease the user-system interface. A simple set of rules is used to select an optimization technique or to switch from one technique to another in an attempt to detect, diagnose, and solve some potential problems. Numerical examples involving finite element based optimal design of space trusses and rotor bearing systems are used to illustrate the applicability of the proposed methodology. Author

A87-36288
AN INTEGRATED APPROACH TO ADVANCED CONCEPTUAL DESIGN
MICHAEL J. LOGAN (LTV Aerospace and Defense Co., Dallas, TX) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 21 p.
(SAWE PAPER 1716)

Cost savings and technical accuracy are both enhanced by a new approach to conceptual design activities for advanced technology aircraft. A graphics-based workstation computer is used to integrate several conceptual design analysis programs into a single, stand-alone conceptual design system. The Vought multi-discipline Aircraft Synthesis Analysis Program (ASAP) is used as the primary design synthesis tool. Additional analyses available include survivability predictions, depending on the user's requirements. The second phase of the program will provide for the development of new configuration generation and analysis capability by incorporating expert system techniques. D.H.

A87-36297#
INTERACTIVE/OPTIMIZATION WEIGHT PREDICTION MODEL
THAKOR SHAH (Bell Helicopter Textron, Fort Worth, TX) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 33 p.
(SAWE PAPER 1731)

An interactive/optimization computer model is described that has been designed to provide a quick reaction synthesis of helicopter preliminary design concepts. With WISORD (Weight Interactive Synthesis and Optimization of Rotorcraft Design), the user need only supply a few basic parameters such as disk loading, payload, range, and design limit load factor. The model will yield 'first-cut' gross weight, weight empty, and fuel required determinations. WISORD can also provide preliminary geometry and performance data to begin initial design. If a more detailed analysis is needed, the model will provide the approximately 300 configuration and criteria inputs required to run the first level computer weight model. Optimization is accomplished by establishing a mathematical relationship between parameters, setting minimum and maximum limits on each, and computing a matrix of weight from which the lightest rotorcraft can be selected. D.H.

A87-36753
APPLICATION OF ARTIFICIAL INTELLIGENCE METHODS [EINSATZ VON METHODEN DER ARTIFICIAL INTELLIGENCE]
H. HOLLA (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 12-17. In German.
(DGLR PAPER 86-100)

Some basic areas of application of artificial intelligence methods, especially knowledge-based systems, in military aircraft are described. Ground-controlled and air-controlled diagnostic and evaluation systems, multisensor systems, and the support of system development are examined. The technology of knowledge-based systems is briefly reviewed, and the most important present problem areas are critically discussed. C.D.

A87-36773
IMPROVED INTEGRATION PROCEDURES FOR FLIGHT SIMULATION [VERBESSERUNGEN VON INTEGRATIONSVERFAHREN ZUR FLUGSIMULATION]
STEFEN NOWACK (Berlin, Technische Universitaet, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 192-200. In German. refs
(DGLR PAPER 86-154)

Explicit, second to fourth order accurate Runge-Kutta procedures suitable for real-time flight simulation are compared. The numerical stabilities, accuracy of results for different inputs, and computation times of the different methods are compared. A second-order system is used for error evaluation, while a fourth-order system is used to determine the effect of frequency neighorhoods on the integration errors. The results of applying two different procedures to the integration of an extensive system are compared using as an example a landing approach and coming to a rolling stop. C.D.

A87-36776
AN APPROACH TO STRUCTURING AND FORMALIZING KNOWLEDGE FOR A DESIGN SUPPORT SYSTEM
NUR EROL and CHRISTIAN FREKSA (Muenchen, Technische Universitaet, Munich, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 215-219.
(DGLR PAPER 86-115)

Architecture and representation structures of a knowledge-based decision support system for aircraft design are described. The most important technical design characteristics of such a system are reviewed, and the various philosophies for computer-based design support are considered in the light of these characteristics. The reasons for the philosophy chosen by the authors are explained, and an interactive knowledge-based design support system based on this choice is described. The structuring of different types of knowledge is emphasized. The language STRUDEL (Structure Description Language), which serves in the system for expressing this knowledge, is described, and aspects of the implementation of the chosen system are discussed. C.D.

A87-36777
AI/EXPERT SYSTEMS - A CONCEPT FOR THEIR APPLICATION IN THE MAINTENANCE AND REPAIR OF AIRCRAFT SYSTEMS [KI/EXPERTENSYSTEME - EIN KONZEPT ZUM EINSATZ IN DER WARTUNG UND INSTANDSETZUNG VON FLUGZEUGSYSTEMEN]
HELMUT SCHEIBENZUBER (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Yearbook 1986 I; DGLR, Annual Meeting, Munich, West Germany, Oct. 8-10, 1986, Reports . Bonn, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1986, p. 220-225. In German.
(DGLR PAPER 86-117)

The use of AI/expert systems for testing at various levels of aircraft maintenance and repair is studied. A concept is presented which will, over the long term and through targeted construction and application of AI/expert systems, lead to significantly improved fault isolation in modern avionics test systems, to optimized testing time, and to improved user friendliness. These improvements are illustrated using the ATLAS linear test program as an example. C.D.

A87-36843
A PROCEDURE FOR SIMULTANEOUSLY STABILIZING A COLLECTION OF SINGLE INPUT LINEAR SYSTEMS USING NON-LINEAR STATE FEEDBACK CONTROL
I. R. PETERSEN (New South Wales, University; Australian Defence Force Academy, Campbell, Australia) Automatica (ISSN 0005-1098), vol. 23, Jan. 1987, p. 33-40. refs

This paper considers the problem of simultaneously stabilizing a finite collection of single input linear systems. This stabilization is achieved using a single non-linear state feedback controller. The stability of the resulting closed loop system is established using a collection of quadratic Lyapunov functions. The main result of this paper is a sufficient condition for simultaneous stabilizability. Furthermore, when this sufficient condition is satisfied, the paper gives a formula for constructing the stabilizing feedback control law. The paper includes an example in which the stabilization procedure is applied to the stabilization of an F4E fighter aircraft. Author

A87-37550#
ADA - FROM PROMISE TO PRACTICE?
JOHN VOELCKER IEEE Spectrum (ISSN 0018-9235), vol. 24, April 1987, p. 44-49.

Ada development systems break sections of code into reusable modules that allow users to rank the priority of jobs and tasks performed by the entire system; this modularity is suitable to the clearly defined priorities of advanced military aircraft computerized control systems. With Ada, the user can also define generics, or general processing routines to handle variables of various types that include data and subroutines. However, Ada's rigid definitions are sometimes a drawback to those who must create development systems for the language; Ada lacks such development tools as debuggers and cross-reference programs. A compiler must be validated separately for each of its target systems. O.C.

A87-38651#
AUTOTESTCON '86; PROCEEDINGS OF THE INTERNATIONAL AUTOMATIC TESTING CONFERENCE, SAN ANTONIO, TX, SEPT. 8-11, 1986
Conference sponsored by IEEE. New York, Institute of Electrical and Electronics Engineers, 1986, 428 p. For individual items see A87-38652 to A87-38682.

Papers are presented on the Hierarchical Integrated Test Simulator (HITS); test program sets development management in the HITS environment; an expert maintenance tool; the rule-based go-chain; advanced microcircuit tester architecture; ATE procurement and management; interface connecting device design for ATE systems; AI-based diagnostic testing on ATE; and automated display generation for improved ATE operator interface. Consideration is given to an RF stimulus generator with agile modulation features; knowledge engineering; AI as applied to advanced ATE; a test language interpreter in Ada; and a unitary-data-base model for electronic design data dissemination. Topics discussed include the benefits of automatic table top testers; vertical compatibility; space-link simulation of airborne multimode radars; a digital technique for the measurement of modulation signals; and the Consolidated Automated Support System. I.F.

A87-38653#
HITS DATPG IMPLEMENTATION TECHNIQUES
RICHARD W. HENNEKE (RCA, Automated Systems Div., Burlington, MA) IN: AUTOTESTCON '86; Proceedings of the International Automatic Testing Conference, San Antonio, TX, Sept. 8-11, 1986 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 23-26.

This paper discusses test program development methods by which the Hierarchical Integrated Test Simulator (HITS) software tool can most effectively be used. HITS is a Digital Automatic Test Program Generator (DATPG) that is used to develop test programs for digital logic circuitry. The test program development methods outlined in this paper take the form of test implementation and augmentation techniques useful in optimizing not only the quality of the user's HITS test program, but the number and type of digital units that can be tested using HITS. Current HITS test program development on digital circuit cards of varied complexity has led to the development of many such techniques. Author

A87-38657#
FEEDBACK FROM THE FRONT - USER CONTRIBUTIONS TO B-52 AVIONICS ATE
JOHN T. NIEDERKORN (USAF, Software Support Center, Robins AFB, GA) and RONALD C. HENDRYX (USAF, Aircraft Avionics Maintenance, Offutt AFB, NE) IN: AUTOTESTCON '86; Proceedings of the International Automatic Testing Conference, San Antonio, TX, Sept. 8-11, 1986 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 59-63.

A Supportability, Maintainability, Acceptability, Reliability, Testability (SMART) approach to the development of ATE is described. The benefits provided by involving users early in the development of testing equipment are discussed. An example in which the SMART approach is employed to develop the a new test set for the Strategic Radar System of the B-52 is presented. I.F.

A87-38661#
AI-BASED DIAGNOSTIC TESTING ON ATE
DOUGLAS W. KERSH, JON J. KASPRICK, and DONALD R. ANDERSON (Boeing Electronics Co., Seattle, WA) IN: AUTOTESTCON '86; Proceedings of the International Automatic Testing Conference, San Antonio, TX, Sept. 8-11, 1986 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 103-106.

The control of the performance of ATE-based diagnostic routines using an AI work station is described. The ATE system employed in this study was composed of a test instrument controller and various test equipment connected to the controller through a bus; the software was a functional test procedure and several diagnostic routines all coded in BASIC. The AI work station software consisted of a master control program written in Smalltalk, a commercial expert system shell written in Franz LISP, and a knowledge base written with OPS5. The unit tested by the AI system was a modified single-card line replaceable unit used on Boeing 757/767 aircraft. It is noted that by using an AI-based ATE concept, single and multiple faults can be isolated to the component level quickly and efficiently with little ambiguity. I.F.

A87-38666#
MICROPROCESSOR BASED UUT TESTING IN A DEPOT ENVIRONMENT
MARY LOU MILLER (USAF, San Antonio Air Logistics Center, Kelly AFB, TX) IN: AUTOTESTCON '86; Proceedings of the International Automatic Testing Conference, San Antonio, TX, Sept. 8-11, 1986 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 165-170.

ATE repair procedures for microprocessor-controlled printed circuit boards are developed. The three principles for developing automated maintenance procedures are: (1) use the system's embedded checks, (2) use the proper type of tester for each unit under test, and (3) make the procedures easy to follow. The ATE equipment employed at the USAF San Antonio Air Logistics Center, in order to develop repair procedures for avionics systems, include the Field Maintenance Processor, In Circuit Test Adapter, and Logic Test System. The testing procedures, which involved dividing the system into blocks for testing; input/output port testing; and interactive emulation, are described. I.F.

A87-38668#
ARTIFICIAL INTELLIGENCE AS APPLIED TO ADVANCED ATE
C. K. ANDERSON and P. DUONG IN: AUTOTESTCON '86; Proceedings of the International Automatic Testing Conference, San Antonio, TX, Sept. 8-11, 1986 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 181-186.

The Knowledge Engineering aspect of Artificial Intelligence which provides the capability to make inferential decisions and to learn (accumulate and refine knowledge) with time has long been identified as a valuable asset in ATE. Development work has been conducted to determine the areas where this technology can be most effectively utilized. The more promising ATE areas are: (1) test logic determination, or fault isolation, (2) test sequence optimization, (3) test language translation, and (4) test station customization. Knowledge Engineering is now maturing to the point where practical applications of Knowledge Based Systems (KBS) can be implemented using this technology. These applications have the potential to provide performance improvements of up to 30 percent. Author

A87-38679#
THE AIR FORCE ORGANIC MATE OPERATIONS CENTER - STATUS AND PLANS
THOMAS FLORES (USAF, San Antonio Air Logistics Center, Kelly AFB, TX) IN: AUTOTESTCON '86; Proceedings of the International Automatic Testing Conference, San Antonio, TX, Sept. 8-11, 1986 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 335-340.

The four components of the modular ATE system (MATE) are examined. The automated acquisition tools (AATs) are software models, programs, and reference data banks used for the acquisition and management of ATE and test program sets (TPSs). The AATs consist of a life cycle cost model, a TPS cost prediction model, a MATE data system, and a software modular library; the functions of these components are described. Consideration is given to the hardware modular verification, the software development and support subsystem, and MATE guides (specify and describe the MATE acquisition process). The selection and training of the personnel for the MATE Operation Center are discussed. I.F.

A87-38680#
ENGINEERING AND APPLICATION OF THE CONTROL INTERFACE INTERMEDIATE LANGUAGE IMPOSED BY MATE
STAFFAN ERICKSON (Support Systems Associates, Inc., Dayton, OH) IN: AUTOTESTCON '86; Proceedings of the International Automatic Testing Conference, San Antonio, TX, Sept. 8-11, 1986 . New York, Institute of Electrical and Electronics Engineers, 1986, p. 341-345.

Use of off-the-shelf hardware and a common programming language are the essence of an Air Force project called Modular Automatic Test Equipment (MATE). The Air Force Weapon Systems Program Offices (SPOs) are levied the responsibility of complying with MATE acquisition concepts and are offered potential life cycle cost savings by adopting these philosophies. With the emerging technology changes, the new support equipment acquisition requirements must include flexible means for adopting a common programming language and the establishment of procedures and control techniques for tracking the language configuration. This paper focuses on the problems with controlling the common programming language ANSI/IEEE Std 716 - 1985 (ATLAS-716) and the Control Interface Intermediate Language (CIIL) described by the System Control Interface Standard. The methods by which the CIIL, and extensions to CIIL, are controlled, managed and updated by the MATE SPO using two software tools are described. Also presented are CIIL language concerns, benefits, as well as future language requirements needed to assure MATE transportability and interchangeability. Author

A87-39016#
SYNTHESIS OF OPTIMAL DISCRETE MULTIDIMENSIONAL SYSTEMS UNDER RANDOM PERTURBATIONS [SINTEZ OPTIMAL'NYKH DISKRETNYKH MNOGOMERNYKH SISTEM PRI SLUCHAINYKH VOZDEISTVIIAKH]
L. N. BLOKHIN and A. A. TUNIK (Kievskii Institut Inzhenerov Grazhdanskoi Aviatsii, Kiev, Ukrainian SSR) Kibernetika i Vychislitel'naia Tekhnika (ISSN 0454-9910), no. 71, 1986, p. 13-17. In Russian.

The paper examines an algorithm for the synthesis of optimal multidimensional discrete control systems under stationary random perturbations from the minimum condition of the integral quadratic quality criterion. The proposed algorithm makes possible the simultaneous synthesis of multidimensional control units in the perturbation-setting and feedback circuits. The results are of interest in connection with the automatic flight control of passenger aircraft. B.J.

N87-22416# Naval Postgraduate School, Monterey, Calif.
THE USE OF A COMPUTER TO OBTAIN FLIGHT MANUAL DATA M.S. Thesis
CHANG W. OH Dec. 1986 88 p
(AD-A176741) Avail: NTIS HC A05/MF A01 CSCL 01B

The one thing among many that must be prepared for every flight is the making of a flight plan. Pilots must use charts or graphs from the flight manual to compute the fuel flow that is essential to flight plan. Since this requires many steps of interpolation to compute the specific conditions that cannot be read directly from flight manual, it is time consuming and increases the probability of making a mistake. This problem obstructs the execution of various mission changes and continuous sorties. A computer program for personal computer or hand-held calculator is developed to compute the desired fuel flow by modifying the equations for an IDEAL airplane. Author (GRA)

N87-22424# National Aerospace Lab., Tokyo (Japan).
PROGRAMMING TECHNIQUES FOR HIGH-SPEED PROCESSING AND VERIFICATION WITH THE NEC SUPERCOMPUTER SX SYSTEM
KINUYO NAKAMURA, MASAHIRO YOSHIDA, and SHINICHI MINEO 1986 55 p In JAPANESE; ENGLISH summary
(NAL-TR-909; ISSN-0389-4010) Avail: NTIS HC A04/MF A01

Various methods of effective FORTRAN programming to increase vectorization rates and conduct high-speed processing of FORTRAN programs for supercomputers are presented. The methods are used to tune up the National Aerospace Laboratory application software package, AFMESH, which is a two-dimensional grid generation program, and INVERSE, which is a two-dimensional airfoil design program. The tuned-up programs are executed with the NEC supercomputer SX-2 system and computing times compared with the times of the original programs show the usefulness of the methods. Author

N87-23162*# Computer Sciences Corp., Mountain View, Calif. Systems Sciences Div.
THE 2GCHAS: A HIGH PRODUCTIVITY SOFTWARE DEVELOPMENT ENVIRONMENT
LARRY BABB *In* NASA. Goddard Space Flight Center Sixth Annual Users' Conference p 111-123 Oct. 1986
Avail: NTIS HC A11/MF A01 CSCL 09B

To the user, the most visible feature of the Transportable Applications Executive (TAE) is its very powerful user interface. To the programmer, TAE's user interface, proc concept, standardized interface definitions, and hierarchy search provide a set of tools for rapidly prototyping or developing production software. The 2GCHAS (Second Generation Comprehensive Helicopter Analysis System) project has extended and enhanced these mechanisms, creating a powerful and high productivity programming environment where the 2GCHAS development environment is 2GCHAS itself and where a sustained rate for certified, documented, and tested software above 30 delivered source instructions per programmer day has been achieved. The 2GCHAS environment is not limited to helicopter analysis, but is applicable to other disciplines where software development is important. Author

N87-23182# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
A GRAPHICS ENVIRONMENT SUPPORTING THE RAPID PROTOTYPING OF PICTORIAL COCKPIT DISPLAYS M.S. Thesis
ALAN J. BRAATEN Dec. 1986 168 p
(AD-A178636; AFIT/GCS/MA/86D-1) Avail: NTIS HC A08/MF A01 CSCL 09B

Attention was focused on the interactive construction of pictorial type cockpit displays from libraries of cockpit displays and symbology. Implementation was based on an object-oriented programming paradigm. This approach provided a natural and consistent means of mapping abstract design specifications into functional software. Implementation was supported by an object-oriented extension to the C programming language. Although this investigation addressed a specific application, the resulting graphic environment is applicable to other areas requiring the rapid prototyping of pictorial displays. Author (GRA)

N87-23192*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
PRODUCT ASSURANCE POLICIES AND PROCEDURES FOR FLIGHT DYNAMICS SOFTWARE DEVELOPMENT
SANDRA PERRY, LEON JORDAN, WILLIAM DECKER, GERALD PAGE (Computer Sciences Corp., Greenbelt, Md.), FRANK E. MCGARRY, and JON VALETT Mar. 1987 107 p
(NASA-TM-89377; SEL-87-001; NAS 1.15:89377) Avail: NTIS HC A06/MF A01; single copies available from NASA/GSFC, Code 552, Greenbelt, Md. 20771 CSCL 09B

The product assurance policies and procedures necessary to support flight dynamics software development projects for Goddard Space Flight Center are presented. The quality assurance and configuration management methods and tools for each phase of the software development life cycles are described, from requirements analysis through acceptance testing; maintenance and operation are not addressed. Author

N87-23194*# Computer Sciences Corp., Hampton, Va.
DESCRIPTION OF AN AERONAUTICAL GEOMETRY CONVERSION PACKAGE: WAVE-DRAG TO LANGLEY WIREFRAME GEOMETRY STANDARD (LAWGS) TO SUPERSONIC IMPLICIT MARCHING POTENTIAL (SIMP)
MICHAEL R. WIESE Mar. 1987 42 p
(Contract NAS1-17999)
(NASA-CR-178299; NAS 1.26:178299; TAO-50015) Avail: NTIS HC A03/MF A01 CSCL 09B

Documented is an aeronautical geometry conversion package which translates wave-drag geometry into the Langley Wireframe Geometry Standard (LaWGS) format and then into a format which is used by the Supersonic Implicit Marching Potential (SIMP) program. The programs described were developed by Computer Sciences Corporation for the Advanced Vehicles Division/Advanced Concepts Branch at NASA Langley Research Center. Included also are the input and output from a benchmark test case. Author

N87-23202*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
APPLICATIONS AND REQUIREMENTS FOR REAL-TIME SIMULATORS IN GROUND-TEST FACILITIES
DALE J. ARPASI and RICHARD A. BLECH Dec. 1986 26 p
(NASA-TP-2672; E-3189; NAS 1.60:2672) Avail: NTIS HC A03/MF A01 CSCL 09B

This report relates simulator functions and capabilities to the operation of ground test facilities, in general. The potential benefits of having a simulator are described to aid in the selection of desired applications for a specific facility. Configuration options for integrating a simulator into the facility control system are discussed, and a logical approach to configuration selection based on desired applications is presented. The functional and data path requirements to support selected applications and configurations are defined. Finally, practical considerations for implementation (i.e., available hardware and costs) are discussed. Author

N87-23204# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.
MULTI-INPUT/MULTI-OUTPUT DESIGNATED EIGENSTRUCTURE (MODES): A COMPUTER-AIDED CONTROL SYSTEM DESIGN PROGRAM M.S. Thesis
MICHAEL E. HOPPER Mar. 1987 211 p
(AD-A179341; AFIT/GAE/AA/87M-2) Avail: NTIS HC A10/MF A01 CSCL 12B

The design engineer can specify the closed-loop response of a system, including both the modes and mode shapes, with the eigenstructure assignment approach to system synthesis. This effort was to create an interactive computer-aided control system design program to enable the designer to use the modern control approach to design a control system with specified response characteristics, or to come as close to the ideal as possible. With the program MODES, the design engineer can easily calculate the feedback gains needed to give the controlled system the optimum response characteristics by specifying the desired eigenvalues and eigenvectors. The singular value decomposition is used to accomplish this. GRA

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A87-35770
CALCULATION OF THE STATISTICAL CHARACTERISTICS OF HIGH-INTENSITY DIFFRACTED ACOUSTIC NOISE [O RASCHETE STATISTICHESKIKH KHARAKTERISTIK DIFRAGIRUIUSHCHEGO AKUSTICHESKOGO SHUMA BOL'SHOI INTENSIVNOSTI]
O. V. RUDENKO and V. A. KHOKHLOVA (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) Moskovskii Universitet, Vestnik, Seriia 3 - Fizika, Astronomiia (ISSN 0579-9392), vol. 27, Sept.-Oct. 1986, p. 31-35. In Russian. refs

A method for calculating the statistical characteristics of nonlinear diffracted noise is proposed with allowance for spatial field incoherence. An example of broad-spectrum noise diffraction is considered which illustrates the mutual influence of temporal and spatial statistics in the linear approximation. B.J.

A87-38106#
THE ROLE OF HELICOPTER NOISE-INDUCED VIBRATION AND RATTLE IN HUMAN RESPONSE
PAUL D. SCHOMER and ROBERT D. NEATHAMMER (U.S. Army, Construction Engineering Research Laboratory, Champaign, IL) Acoustical Society of America, Journal (ISSN 0001-4966), vol. 81, April 1987, p. 966-976. refs

The role of perceived building vibrations and rattle in human response to helicopter noise (in terms of percentage of population highly annoyed) was studied using the A-weighting and C-weighting to assess response. Test participants were placed in a wood-frame home, a mobile home, or outdoors. To create a wide range of single-event flyby SELs, the helicopter's slant distance from the test structures was varied. It was found that when the noise induced noticeable vibrations, negative response increased significantly. However, neither A-weighting nor C-weighting could properly assess human response when the helicopter noise excited high levels of vibration and rattle. The presence or absence of high levels of noise-induced vibration was strongly dependent on the helicopter's slant distance: slant distances shorter than 500 ft virtually ensured high levels of noise-induced vibration and rattles, whereas at slant distances in excess of 1000 ft there occurred little or no vibration or rattle. I.S.

N87-23248# Westland Helicopters Ltd., Yeovil (England).
ACOUSTIC TESTING OF SIMPLIFIED CABIN BOX, PHASE 1 Final Report
A. W. ROSSALL Feb. 1986 58 p
(Contract MOD-K/A12/1668)
(RP-698; BR100264; ETN-87-99820) Avail: NTIS HC A04/MF A01

Acoustic transmission loss and radiation efficiency properties of three different types of skin panels fitted to a simple box shaped framework (plain aluminum, aluminum with stringers, fibrelam) were measured. The plain aluminum skin is superior to the aluminum skin with stringers, which is superior to fibrelam (although doubts are expressed as to the validity and appropriateness of radiation efficiency measurements on a structure such as the box). Data was provided for correlation with SEA predictions, and the box is found to respond in a linear fashion to various levels of input force. ESA

N87-23250# Army Aviation Research and Development Command, Moffett Field, Calif. Aeroflightdynamics Directorate.
PREDICTION OF HIGH-SPEED ROTOR NOISE WITH A KIRCHHOFF FORMULA
TIMOTHY W. PURCELL, ROGER C. STRAWN, and YUNG H. YU 1987 10 p
(AD-A178982) Avail: NTIS HC A02/MF A01 CSCL 20A

A new method has been developed to predict the impulsive noise generated by a transonic rotor blade. The formulation uses a full-potential finite-difference method to obtain the pressure field close to the blade. A Kirchhoff integral formulation is then used to extend these finite difference results into the far field. This Kirchhoff formula, written in a blade-fixed coordinate system, requires initial data across a plane at the sonic radius. This data is provided by the finite-difference solution. Acoustic pressure predictions show excellent agreement with hover experimental data for two hover cases of 0.88 and 0.90 tip Mach number, the latter of which has delocalized transonic flow. These results represent the first successful prediction technique for peak pressure amplitudes using a computational code. GRA

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law, political science, and space policy; and urban technology and transportation.

A87-36307
INTERRELATIONSHIP OF WEIGHT AND COST REDUCTION
JOSEPH W. TURNER (Bell Helicopter Textron, Fort Worth, TX) SAWE, Annual Conference, 45th, Williamsburg, VA, May 12-14, 1986. 10 p.
(SAWE PAPER 1748)

The methodology developed and currently used by Bell Cost Analysis Engineering to review Weight Improvement Program (WIP) proposals is described. In the early preliminary design stage for a helicopter or VSTOL aircraft, a design-to-cost (DTC) team has the objective of establishing life cycle cost as a technical parameter, equal in importance to performance and schedule considerations. The team utilizes computerized DTC models that contain various cost estimating relationships (CERs) to project the aircraft unit production cost. These CERs include weight-sensitive parameters and are based on early design concepts. The DTC team recommends approval or disapproval of WIP suggestions to management. An example is used to illustrate the implementation of the value-per-pound methodology: the case of a component that could be reduced in weight by selective chem-milling, at a cost of $1600 per pound saved; the proposal was rejected as to costly and the part redesigned to save weight at no increased cost. D.H.

A87-37015
NEGLIGENCE OF THE AIRCRAFT COMMANDER AND BAD AIRMANSHIP - NEW FRONTIERS
R. I. R. ABEYRATNE (Airlanka, Colombo, Srilanka) Air Law (ISSN 0165-2079), vol. 12, Feb. 1987, p. 3-10. refs

International aviation laws attributing absolute responsibility for the safe operation of the aircraft to the pilot and rules governing the professional conduct of the pilot are reviewed. Liability in negligence related to the duty of care is examined, and a decided case concerned with the safe operation of an aircraft is presented. The need to consider medical factors when assessing the liability of the pilot is discussed. I.F.

A87-37016
AVIATION ANTITRUST - INTERNATIONAL CONSIDERATIONS AFTER SUNSET
PATRICIA BARLOW Air Law (ISSN 0165-2079), vol. 12, Feb. 1987, p. 11-28. refs

The role of antitrust laws in the international air transportation industry during the transition from a regulated to a deregulated economic environment is studied. Antitrust laws and the air transportation industry prior to 1978 are examined. Consideration is given to the antitrust authority of the CAB under the Federal Aviation Act of 1958, the doctrines of primary and exclusive jurisdiction, and express and implied antitrust immunity provisions. The factors which caused the deregulation of the air transportation industry in 1978, such as the approval of the Skytrain concept, negotiations of liberal bilateral air transport agreements, and the IATA Show Cause Order, are discussed. I.F.

A87-37017
WITH TWIN-JETS ACROSS THE NORTH ATLANTIC - A LEGAL REFLECTION
RONALD SCHMID Air Law (ISSN 0165-2079), vol. 12, Feb. 1987, p. 29-36. refs

The operation of twin-engine aircraft on the North Atlantic routes is considered from a legal perspective. Engine failures and the limited number of suitable alternative airports are discussed as potential safety hazards in the operation of twin-engine aircraft

across the North Atlantic. The applications of Article 25 of the Warsaw Convention (unlimited liability), and gross negligence or willful misconduct laws to cases involving passenger injury, cargo and bagagge damage, or delays in the transport of passengers, cargos, and baggages due to the operation of twin-engine aircraft on the North Alantic routes are examined. I.F.

A87-37566#
THE ROLE OF THE INTERNATIONAL CIVIL AVIATION ORGANIZATION ON DEREGULATION, DISCRIMINATION, AND DISPUTE RESOLUTION
PAUL STEPHEN DEMPSEY (Denver, University, CO) Journal of Air Law and Commerce (ISSN 0021-8642), vol. 52, Spring 1987, p. 529-583. refs

The role of ICAO in maintaining efficient international air transportation is discussed. The extraterritorial application of national legislation regarding antitrust and competition is examined. Considertion is given to the establishment and enforcement of international air carrier tariffs, the elimination of bias in airline computer reservation systems, preventing discrimination in airport navigation and user fees, and the reciprocal elimination of foreign taxation. The ICAO procedures for resolving disputes, and various types of sanctions are described. Examples of dispute resolutions are provided. I.F.

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GENERAL

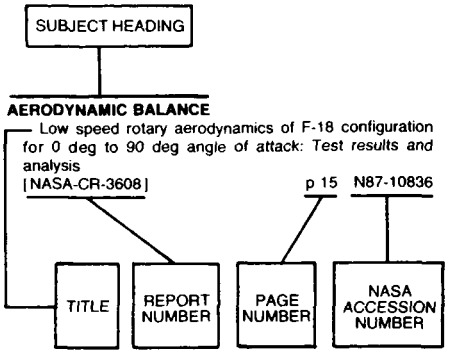
A87-35425
REPORTED IN-FLIGHT INCAPACITATION - THE EARLY BIRDS OF 1911
ALLEN J. PARMET (USAF, Hospital, Vandenberg AFB, CA) and K. E. UNDERWOOD GROUND Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 58, March 1987, p. 276-278. refs

Numerous fatal accidents marred the early years of aviation, but not until 1911 was the first accident attributed to inflight incapacitation of the pilot. Two such accidents occurred in 1911 and were reported to be due to medical causes. The present review of the circumstances surrounding these two accidents leads to different conclusions. They are believed to have been caused by pilot error, and not by medical causes. So the first accident due to inflight incapacitation of the aircrew for medical reasons still remains unknown. Author

N87-22602*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LANGLEY AEROSPACE TEST HIGHLIGHTS - 1986
May 1987 101 p
(NASA-TM-89144; NAS 1.15:89144) Avail: NTIS HC A06/MF A01 CSCL 05A

The role of the Langley Research Center is to perform basic and applied research necessary for the advancement of aeronautics and space flight, to generate new and advanced concepts for the accomplishment of related national goals, and to provide research advice, technological support, and assistance to other NASA installations, other government agencies, and industry. This report highlights some of the significant tests which were performed during calendar year 1986 in Langley test facilities, a number of which are unique in the world. The report illustrates both the broad range of the research and technology activities at the Langley Research Center and the contributions of this work toward maintaining United States leadership in aeronautics and space research. Author

Typical Subject Index Listing



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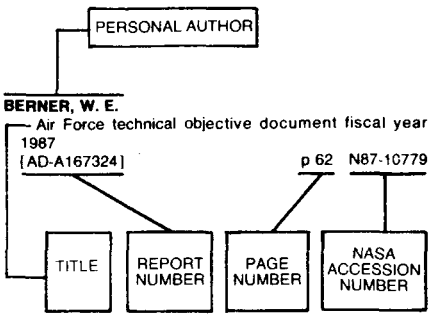

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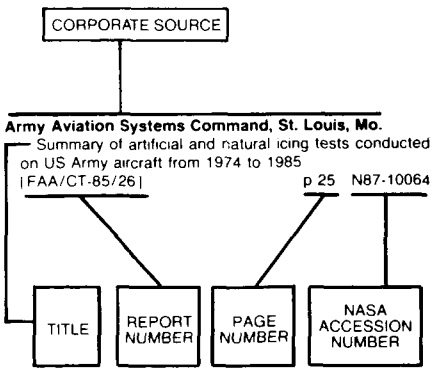

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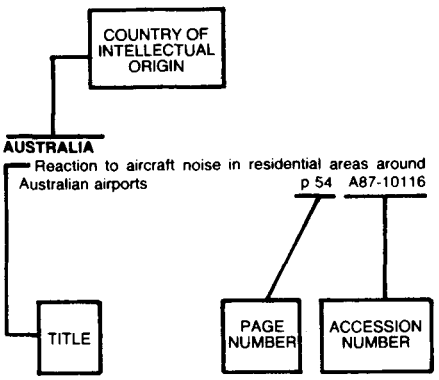

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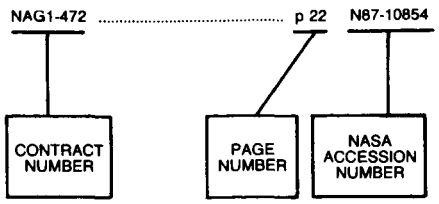

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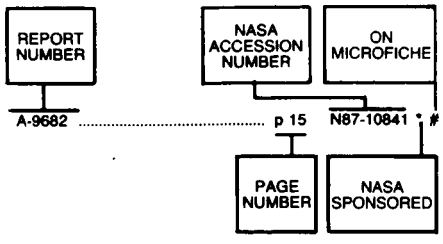

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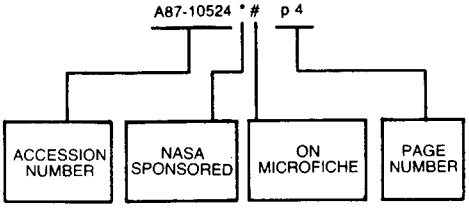

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1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA SP-7037 (217)		

4. Title and Subtitle	5. Report Date
Aeronautical Engineering A Continuing Bibliography (Supplement 217)	September, 1987
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
	10. Work Unit No.
9. Performing Organization Name and Address National Aeronautics and Space Administration Washington, DC 20546	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

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17. Key Words (Suggested by Authors(s))	18. Distribution Statement
Aeronautical Engineering Aeronautics Bibliographies	Unclassified - Unlimited

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